IMMEDIATE POST CATASTROPHIC INJURY MANAGEMENT IN RUGBY UNION. DOES IT AFFECT OUTCOME?

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List of Abbreviations

ASCI – Acute Spinal Cord Injury

SES- Socioeconomic status

TBI- Traumatic Brain Injury

SARU- South African Rugby Union

SA Rugby- South African Rugby

CBPJPF - Chris Burger/ Petro Jackson Players Fund

Abstract

Background:

Rugby union ('rugby') has a high injury risk. These Injuries range from having minor consequences to catastrophic injuries with major life changing consequences. In South Africa, previous research indicated that the risk of catastrophic injury was high and that the immediate management was sub-optimal, worsening the injury outcome. In response, the South African Rugby Union launched the BokSmart nationwide injury prevention programme in 2008. Through education - mainly of coaches and referees - this programme aims to improve the prevention and management of catastrophic injuries. Moreover, the programme began administering a standardised questionnaire for all catastrophically injured players to assess the prevention and management of these injuries.

Objectives:

To assess whether factors in the immediate pre- and post-injury management of catastrophic injuries in rugby were associated with their outcome. In addition, as part of the BokSmart programme in Rugby in South Africa, there were modules developed as part of the education material delivered to referees and coaches in their workshops that deal specifically with safety in the playing environment, and the correct management of catastrophic injuries. We assessed whether these protocols within the modules were implemented.

Design:

A prospective, cohort study conducted on all catastrophic injuries in rugby collected through a standardised questionnaire by BokSmart between 2008 -2014.

Methods:

Secondary analyses were performed on the information collected on all rugby-related catastrophic injuries in BokSmart's serious injury database. Injury outcomes were split into 'permanent' (permanently disabling and fatal) and 'non-permanent' (full recovery/ "near miss"). Immediate post injury management factors as well as protective equipment and ethnicity were analysed for their association with injury outcome using a Fisher's exact test.

Results:

There were 87 catastrophic injuries recorded between 2008 and 2014. Acute spinal cord injuries (ASCI) made up most of the catastrophic injuries (n=69) with traumatic brain injuries

(TBI) the second most common (n = 11 injuries). There were 7 cardiac events. Black African players were associated with a 2.4 times higher proportion of permanent outcome that the injured White players (p=0.001). There was no association between any protective equipment or injury management (including optimal immobilization, time and method of transport taken to hospital) and ASCI outcome (non-permanent vs. permanent)

Conclusions:

Neither immediate post-injury management, nor the wearing of protective equipment was associated with catastrophic injury outcome in these South African rugby-related injuries. This might indicate that the initial injury is more important in determining the outcome than the post-injury management and associated secondary metabolic cascade, as proposed by some experts in this area. Moreover, that ethnicity was associated with ASCI outcome in this study is indicative of the wider problems in South Africa; not only specific to rugby. It is recommended that BokSmart continue to focus their programme in low socioeconomic areas that play rugby in South Africa.

Keywords:

“Rugby”, “Acute Spinal Cord injuries’’, “Traumatic Brain Injuries”, “Catastrophic Injuries”, Socio Economic Status”

Chapter 1

Catastrophic injury in rugby. Statement of the problem.

Rugby union ('Rugby') is currently the most played collision sport in the world (1). Unlike Ice Hockey and American Football, rugby is played with minimal padding or protective equipment. The potential for catastrophic injury in rugby was recognised as far back as 1977, when spinal cord injuries were reported (2). This resulted in various regional governing bodies amending laws to make the game safer (3). However, 20 years later there were still no/few national governing bodies that had a catastrophic injury database, or had attempted to document the incidence, causes and outcomes of catastrophic injuries in rugby. Over the previous ten years, the incidence of catastrophic injuries has been measured in rugby in many countries (4) and national databases have been set up to record these injuries (5). The incidence of catastrophic injuries has been reported between 0.6 and 2.0 injuries/ 100,000 rugby players (6,7). In South Africa this figure has been recorded as 1 injury/100,000 players (7). Although this risk is regarded as "acceptable" on the United Kingdom's Health and Safety Executive scale, it is high compared to other sports (7). Also, it has been documented that up to 56 % of catastrophic injuries in rugby are preventable (8,9). If this is correct, then there is significant scope within the framework and laws of the game to lower the incidence of catastrophic injuries.

According to World Rugby in its board guidelines of 2011 (10) "*It is the responsibility of those who coach or teach the Game to ensure that players are prepared in a manner which ensures compliance with the Laws of the Game and in accordance with safe practices*." And "*It is the responsibility of players to ensure that they are physically and technically prepared in a manner which enables them to play the Game, comply with the Laws of the Game and participate in accordance with safe practices*."

It is this guideline that has resulted in the regulatory bodies of rugby to look at law changes and guidelines to support and minimise the risk of catastrophic and non-catastrophic injuries. Since 2008, the South African Rugby Union (SARU) has collected data on all catastrophic injuries and “near miss” (without permanent disability) injuries in rugby. The inclusion of near miss injuries, was unique but relevant, as the mechanisms causing near miss injuries are similar to those causing spinal cord damage; hence effective interventions can be developed by investigating these injuries (11). The inclusion of near misses also gives a comprehensive reflection of catastrophic injury risk.

In June 2008 BokSmart, an injury prevention and education programme for rugby that targets coaches and Referees, was launched. This was a collaborative project between SARU and the Chris Burger/ Petro Jackson fund (CBPJF). Its mission was to apply scientific principles to make the game safer. The programme targets coaches and referees and educates them on a basic standard of prevention, knowledge, and care (12). Modules within the programme deal specifically with safety in the playing environment. These modules detail minimum emergency equipment required for a rugby game to take place safely. Studies have shown the benefit of rugby education programmes in New Zealand (RugbySmart) (13). and South Africa (BokSmart) (14).

Since 2008, BokSmart has prospectively recorded catastrophic injury data in a centrally controlled database. Catastrophic injuries were defined by SARU as (7):

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 centre.

This definition included Acute Spinal Cord Injuries (ASCI); Traumatic Brain Injuries (TBI) and Cardiovascular events (Cardiac).

Serious Injuries incurred during rugby training or matches are reported through the national Spineline emergency number, via hospitals and medical practitioners and rugby union administrators in both amateur and professional rugby. There is an incentive to report these injuries as the CBPJPF provides financial assistance to injured players where possible (7). Data on the period before, during and after the injury incident are recorded using a detailed questionnaire (72 questions) (Appendix A). The questions were derived from information BokSmart provided regarding safety in the playing environment (15), to reduce the rate of catastrophic injury. Any factor associated with reducing or modifying catastrophic injuries was documented in the catastrophic injury questionnaire. Factors associated with improving outcome such as protective equipment; qualification of first responder; time taken to get patient to definitive care, and emergency equipment used were assessed. The BokSmart Serious Injury Case manager (SICM) consults the injured player and/or their family to get information about the circumstances of the injury. There is evidence that the incidence of catastrophic injuries is decreasing in youth, and remaining similar in seniors(7). It is not known whether management before during or after the injury is contributing to this pattern. This is an important question with practical outcomes and sets the scene for this thesis.

The next step in this thesis is a discussion of the literature on injuries in rugby. This section will examine the mechanism of injury. This will be followed by sections on BokSmart, incidence of catastrophic injuries in rugby, phase of play and ASCI, ethnicity and ASCI, protective equipment of ASCI and time of definitive treatment following injury. This will provide the background to the experimental phase of this thesis.

This section is followed by a study that has two aims. The primary aim of the study was to determine whether the BokSmart programme's safety and educational components with specific regard to safety in the playing environment and emergency action plans, have been adhered to and implemented following a serious injury. A secondary aim was to assess whether these BokSmart programme guidelines were associated with improved injury outcomes. The data were summarized and practical recommendations made in the final chapter (Chapter 4).

Chapter 2

Injuries associated with rugby: a narrative review with particular emphasis on catastrophic injuries.

Background

Rugby Union is a collision sport with more than 126 countries registered with World Rugby, the sport's international governing body. There are more than 7 million registered and unregistered players making it the most popular collision sport in the world (16). Catastrophic injuries, although uncommon, do occur in rugby and their outcomes may be permanent and life changing. Consequently, prevention of these injuries through law amendments has been prioritised by World Rugby.

Many studies have documented changes in injuries after law changes. As the injury rate in matches is 27 times higher than in training (17), the laws governing these games, and the application thereof needed to be studied to determine if law changes can make the game safer, or may have a negative effect on the safety of the game. Scrum engagement law changes have been trialled in different countries. In January of 2007, New Zealand scrum laws were changed to reduce the impact force and reduce the number of scrum collapses (18). This was implemented in New Zealand through their RugbySmart programme, a compulsory rugby education programme for coaches and referees. Injury rates were compared at the end of the 2007 season through the assessment of claims filed for acute moderate and serious head and neck injuries with the Accident Compensation Corporation in New Zealand. They showed a decline in scrum related injury claims, and concluded that these laws had a positive benefit. No Acute Spinal Cord Injuries (ASCI) were recorded in 2007. The last recorded ASCI in rugby in New Zealand was in 2004, so no conclusions could be made on whether the law changes would affect catastrophic injury rate and longer term monitoring was required (18).

In 2008, the International Rugby Board (IRB, now "World Rugby") piloted Experimental Law Variations (ELV) in professional rugby in South Africa. These laws included administrative, procedural, technical and player contact law amendments. The player contact law changes had the potential to lower injury rates. However, in this study, this was not the case as injury rates after the implementation of these ELV's in Super rugby and Vodacom Cup were similar to injury rates in the United Kingdom where the old laws were still in effect. They reported no significant differences in injury rates between the two groups (19). Unfortunately, the study had some limitations. The major limitation was that all previous seasons in South Africa prior to the study, grouped match day and training injuries together, thus no comparison could be made in the same competition between pre and post implementation of the ELV's. Other studies have provided evidence, to motivate for law changes, where injury rates were unacceptable. For example, in South Africa, the International Rugby Board through its affiliate national member, the South African Rugby Union (SARU) approved the trial and implementation of a new set of scrum laws designed to reduce injury. This decision was based in part from the evidence provided by the BokSmart programme, a national rugby safety programme (20). This programme showed that the largest number - 33 % (n=20) of all catastrophic injuries between 2008 and 2011 occurred in the scrum phase. Of these - 90 % (n=18) were ASCI and 13 had a permanent outcome (3). The scrum law changes in junior and amateur rugby were ratified on 6 December 2012, and came into effect 1 January 2013. These laws depowered the scrum and changed the engagement process to "Crouch-Bind-Engage". In the professional game, World Rugby agreed that the "Crouch-Bind-Set" scrum engagement process be adopted as a global trial with effect from September 2013.

However, it is only over the last decade that the incidence of catastrophic injuries has been measured in rugby and national databases in France, New Zealand, Australia and South Africa record these injuries (4, 21-23, 24). Also, many studies around the world have reported on catastrophic injuries. The earliest studies identified the scrum, and those players playing in the front row to be the players most at risk for sustaining a catastrophic injury (4, 8). More recently, there has been a change in injury pattern with the tackle phase becoming the most common phase associated with ASCI (9, 25). Position-specific load has been measured in professional rugby players through video analysis. According to this analysis, loose forwards and inside backs have the highest load, including meters run, contact and high energy involvement, and reduced recovery time between involvements (26). These load changes as well as tactical and law changes over the years has been proposed as an explanation for the change in injury patterns. Despite the change in pattern of play being associated with injury, the scrum remains the phase associated with the highest number of permanent outcomes (4,21,23).

Mechanism of Injury

Conclusively determining the mechanism of ASCI in real world situations is extremely difficult and fraught with challenges. The commonest mechanism proposed in ASCI occur in rugby when the neck is forced into hyperflexion (27). This is commonly seen in scrumming injuries. The second most common mechanism of ASCI proposed by Kuster et al in ex vivo studies is when the neck undergoes axial compression or loading with primary (C shape) or secondary (Serpentine) buckling (27). This mechanism occurs in the tackler during the illegal tackle; specifically, the outlawed spear tackle and the head first conventional tackle. Over extension of the neck has also been implicated in ACSI. Despite the difficulty in determining the mechanism of ASCI, there are practical steps that rugby administrators have been able to apply to make the game of rugby safer. 1/Scrum time, configuration and player engagement can be controlled. 2/ Tackles can be controlled and regulated to outlaw the head first and spear tackle, and to minimise head to ground contact. Current laws have been changed to make the game safer by depowering the scrum and preventing spear or tip/ high tackles. Another revision to the law penalises players making contact with the player in the air (28). This helps the player to land safely.

In the Foreword, to the Laws of the Game Rugby Union. "*It is the responsibility of those who coach or teach the Game to ensure that players are prepared in a manner which ensures compliance with the Laws of the Game and in accordance with safe practices.*" And "*It is the responsibility of players to ensure that they are physically and technically prepared in a manner which enables them to play the Game, comply with the Laws of the Game and participate in accordance with safe practices.*" (10). It is this principle of safety that has resulted in World Rugby consistently examining laws and making changes to minimise the risk of catastrophic and non-catastrophic injuries.

Bohu et al., studied ASCI in French amateur and professional rugby and reported on 37 catastrophic injuries over a ten-year period (1996 -2006). They showed there was a decrease in catastrophic injuries over this period from 2.1 injuries / 100,000 players to 1.4 injuries / 100,000 players (4). The highest incidence occurred among the hookers and most of the injuries occurred in the scrum. They attributed the reduction in incidence of ASCI in France after 2001 to changes in scrum laws, particularly at the amateur level. The introduction of a rugby passport that specifies the competency of the player to play in the front row was also a contributory factor.

Likewise, Berry et al from Australia (21) and Burry from New Zealand (23) showed the scrum to be the most common phase of rugby associated with cervical injuries. They also showed the hooker was the player with the highest risk. They showed small increases in the incidence of cervical injuries in Australia from 1986-2003 (21) and in New Zealand from 1973-1978 (23). Similar outcomes were reported in Argentina (29) where 18 ASCI were registered between 1977 and 1997. There was an average 0.9 injuries / 100,000 players per year over 20 years. There has been a trend for a small increase of 1.4 cases / 100,000 players per year over last ten years. Fourteen injuries (78 %) involved forwards of which 9 (64 %) were hookers. The scrum phase was implicated in 11 (61 %) cases. A recent paper by Brown showed the methodology used to calculate relative incidences in phase related injuries may be under-reporting scrum related injuries (30). This is because there are fewer scrums per game compared to tackles. Shelly et al, reported on 12 ASCI's in Ireland between 1995 and 2004. They reported the tackle phase was the most common phase implicated in ASCI. They reported a 66 % (n=8) permanent outcome of ASCI. In addition, there was a significantly higher incidence of ASCI in senior rugby players vs. junior rugby players (83 %; n=10) (9).

In South Africa, between 1985 and 1989, 40 ASCI were documented in the spinal unit at the Conradie hospital in the Western Cape (24). The tackle accounted for 50 % (n=20) of ASCI, compared to the scrum, which accounted for 40 % (n=16). In addition, the tackle was associated with a higher percentage of permanent outcomes. The higher number of tackle-related ASCIs and permanent outcomes was thought to be due to illegal and incorrect tackle technique. The ball carrier was injured in 60 % (n=12) of the tackle phase injuries. The now illegal high tackle was thought to be the cause, as this tackle often forced the neck into flexion with rotation. The dive, or spear tackle where incorrect tackle technique results in the tacklers neck being forced into flexion was implicated in the tackler related ASCI's (24).

Another study conducted on players in the Western Cape region in South Africa in the 1990's, showed that more injuries occurred in the tackle situation than scrums. There was also a higher number of ASCI in backs compared to forwards. Centres and Fly halves were the players most at risk. The scrum was the phase of play associated with the highest risk for front row forwards (8).

All the ASCIs and Traumatic Brain Injuries (TBI) between 2008 and 2011 in South Africa were recorded in the BokSmart database. An analysis of these data showed an incidence of 2 injuries / 100,000 players (7). The novel finding was that permanent ASCI were more frequent in senior rugby (4.52 injuries / 100,000 players) compared to junior rugby (0.25 injuries / 100,000 players). In this South African study, 'junior' rugby was synonymous with 'schoolboy' rugby, and included U7 to U19 age groups. Senior rugby included all male and female rugby players, amateur and professional older than the U19 group (7). In this study the hooker remained the position at most risk, being involved in 46 % of all permanent ASCI. Eighty-three % of permanent ASCI resulted from the scrum phase of play. These results were attributed to the law variations between junior and senior rugby, as well as the characteristics of senior rugby, specifically infrequent training and conditioning (7).

A retrospective case analysis of ASCI in national under 19's (junior rugby) in Great Britain and Ireland recorded 36 ASCIs of which 16 (44 %) had a permanent outcome (25). Forty-seven % occurred in the tackle phase and 36 % in the scrum. Consistent with other studies, the scrum has the highest percentage of permanent outcomes (61 %). Once again, there was no registry available in this country, making case-by-case comparisons difficult (25).

Injury prevention and BokSmart

Besides law changes, nationwide injury prevention programmes have also been effective means of reducing catastrophic injuries in rugby. The first programme was launched in New Zealand in 2001 (RugbySmart). This injury prevention programme was compulsory for all coaches and referees to attend. After 5 years, an evaluation of the effectiveness of the programme showed a reduction in injury claims per 100,000 players in most areas the programme targeted including catastrophic injuries (18). Since 2008 the South African Rugby Union (SARU) has collected data on all catastrophic injuries and near misses in rugby through the Chris Burger/ Petro Jackson Players Fund (CBPJPF) initially and later BokSmart. BokSmart was adapted with permission from the RugbySmart programme and was launched in June 2008 (20). The BokSmart programme is a rugby safety programme that targets coaches and referees with education. BokSmart evolved from collaboration between SARU and the CBPJPF (20). BokSmart's mission is to make the game safer through the education and certification of referees and coaches. The BokSmart program has four main components (20):

1. Rugby Safety Workshops – this is the cornerstone of the programme and all coaches and referees, involved in rugby in South Africa under the auspices of SARU must attend a free workshop every 2nd year. The online and print material are presented at the workshops by accredited trainers. Coaches and referees must be BokSmart accredited before they can officiate in training and matches. Currently 114,557 coaches and referees have been trained. This includes 78,426 certifications and 36,131 re-certifications. (Viljoen, *personal communication*)

2. Free online material- this can be downloaded from the programme's website: www.BokSmart.com. This material provides research on a wide range of rugby related topics, including strength and conditioning and sports medicine. There are also evidence-base articles with a practical application.

3. The BokSmart Rugby Medic Program - an open to all, entry-level rugby-related first-aid short course with a specific focus on head, neck, and spine injuries. This programme is aimed at implementing appropriate immediate field-side care particularly in underprivileged

communities; this is augmented by the donation of essential equipment such as spine boards and cervical collars.

4. The BokSmart Spineline - a toll-free hotline that provides advice on potentially serious rugby-related head, neck, and spine injuries and facilitates ambulance transport to the nearest appropriate medical facility, where applicable.

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 centre*" (31). According to this definition, permanent injuries include fatalities. This definition also considers "near misses". These are injuries to the head, neck, spine or brain that did not result in any permanent disability. The decision to broaden the scope of the definition was made to fully assess the catastrophic injury burden, as the mechanism of action in near misses is identical to the more severe permanent outcomes (32).

In South Africa, Brown et al have published data from the BokSmart database (33). This study showed that the incidence of catastrophic injuries has been reduced significantly in junior players from 6.5 injuries per season pre BokSmart implementation (2008-2009) to 4.0 injuries / season in the 4 years' post introduction of the BokSmart program (2010-2013) (33). However, this decrease in catastrophic injuries did not occur in the senior playing population (6.0 injuries / season before and 7.3 injuries/ season after BokSmart). Certain methodological limitations have been noted. Specifically, the assumption that junior player numbers remained constant over this period, and that the methodology used can with certainty, attribute the reductions to the programme itself or other factors, including normal variation.

Previous studies have shown a reduction in catastrophic injuries following rugby education programmes in many countries including New Zealand (RugbySmart) (13) and South Africa (junior players only)(BokSmart) (33, 20). However, there has yet to be a study determining if the education programmes on player welfare have been implemented, and if implemented whether they were effective. As part of the BokSmart programme in South Africa, modules were developed as part of the education material delivered to referees and coaches that deal specifically with safety in the playing environment. These modules detail the minimum emergency equipment and staff required for a rugby game to take place safely, at all levels. The modules also define the emergency personnel required, and the minimum qualifications required for a game to take place safely. This efficacy of these modules in affecting the implementation of emergency protocols has not been determined.

Incidence of catastrophic injuries in rugby

The incidence of catastrophic injuries in rugby varies globally (Table 1). The incidence of catastrophic injuries in sport was defined by Fuller as being "acceptable" if there are less than 2 injuries / 100,000 players per year, and "tolerable" if there are between 2 and 100 injuries / 100,000 players per year (6). Within the framework of risk in a sport, the incidence of catastrophic injuries in rugby is thus regarded as "acceptable"; however, it is high compared to other sports. For example, the incidence is 0.19 injuries / 100,000 players per year in soccer (34).

Table 1: Incidence of catastrophic injuries in rugby in different countries

Country	Incidence/100,000 players	Source
England	0.8	Fuller 2008
Ireland	0.9	Fuller 2008
South Africa	1.0	Brown 2013
Argentina	1.9	Fuller 2008
New Zealand	4.2	Fuller 2008

France	1.5	Bohu (10-year average)
Australia	4.4	Fuller 2008
Fiji	13.9	Fuller 2008

Kew et al (1991) showed that 56 % of catastrophic injuries in rugby are self-reported as being potentially preventable (8). This has also been shown by Shelley et al (2006) who looked at ASCI in Irish rugby between 1995 and 2006. Six out of 12 (50 %) ASCI were self-reported as being preventable (9). However, the risk of catastrophic injury remains even when the game is played strictly within the current laws of the game, which have incorporated amendments due to safety concerns. This suggests there is scope within the framework and laws of the game to lower the incidence of catastrophic injuries in rugby.

In South Africa, the unacceptable incidence of catastrophic injuries was flagged and reported on, in 1991 (24) and again in 1995 by Professor Noakes and colleagues in an editorial to the British Journal of Sports Medicine (35). In addition, the lack of a national registry documenting these injuries was highlighted.

Ethnicity and ACSI

In most countries ethnicity is not considered when causes of ACSI are analysed. However, this is not the case in South Africa where ethnicity has been used as a proxy for socioeconomic status (SES) (36). In unequal societies, such as South Africa, with a history of institutionalised racism, health and medical problems have a particular prevalence in ethnic groups that are longstanding victims of material deprivation and health care inequities (37). This may partly explain ethnic-related size (stature and mass) differences with players from a higher SES generally being bigger than players from a lower SES (38). A recent South African study showed that this manifested as differences in size between ethnicities (38). Elite U18 South African rugby players were followed over ten years from 2002 until 2012, and their self-reported body mass was measured. In this study, White players were 9.8 kg heavier than Black African players, who in turn were 2.3 kg heavier than Mixed Ancestry players. White players were also taller than Black African players (7.0 cm), and Black African players were in turn taller (0.5 cm) than Mixed Ancestry players. Body mass increased similarly in all races between 2002 and 2012 (38). These differences are important for two reasons; (i) in transforming the game to make it representative of the population, and (ii) Black African and Mixed Ancestry players have a poorer outcome following a catastrophic injury (39). A previous study on the demographics of ASCI's in rugby showed a higher percentage of catastrophic injuries occurred in the Black African players. Also, there was a worse outcome in this group, with a higher number of permanent outcomes (39). Similarly, a recent study showed there are significant differences in catastrophic injury rates and proportional distribution across the various provincial unions in South Africa (40). It has been reported that there are just under 300 000 players in South Africa (40), of which 54 % are found within the smaller metropolitan and rural areas (41). Differences in SES impacts directly on the access to adequate nutrition, conditioning equipment, playing environment, protective equipment, emergency equipment and trained medical personnel.

Between 1980 and 2007, 264 rugby related ASCI were identified, in South Africa. One hundred and eighty-three of these injuries were studied in a retrospective case series study (39) using a detailed questionnaire (Appendix A). The majority (40 %) of ASCI's occurred in White players, 32 % in Mixed Ancestry players and 21 % in Black African players. Only 10 % of Black African players who sustained an ASCI had full recovery compared to 56 % of White players and 34 % of Mixed Ancestry players. This study was the first to define the extent of catastrophic injuries in rugby in South Africa, but was limited by the absence of a centralised, national database, and incomplete recall of events surrounding the initial ASCI (39). Of concern was how ethnicity affected the outcome of the ACSI. Mixed Ancestry and Black African players generally had poorer outcome. This was attributed to the inequalities in pre-democratic South Africa (pre-1994) in education, coaching and access to medical resources. This was supported by the finding that less than 50 % of Mixed Ancestry and Black African players had medical cover, and 49 % waited longer than 6 hours for definitive medical care. A further 65% received no medical compensation or support after the injury. In addition, medical personnel were only present at 50 % of the games where ASCI occurred.

Sixty-four % of all players visited more than one facility before having definitive treatment (39).

However, these medical care inequalities are not unique to rugby and may reflect the broader SES disparity in South Africa (36). South Africa has been consistently regarded as the most inequitable country in the world (www.data.worldbank.org) with the Gini index being between 0.660 and 0.669 and widening annually. The Gini coefficient (sometimes expressed as a Gini ratio or a normalized Gini index) is a measure of statistical dispersion intended to represent the income or wealth distribution of a nation's residents, and is the most commonly used measure of inequality. This is a measurement of the income distribution of a country's residents. This number, which ranges between 0 and 1 and is based on residents' net income, helps define the gap between the rich and the poor, with 0 representing perfect equality and 1 representing perfect inequality. This inequality extends to South African health services where the poorest quintile is reported to receive less than 10 % of health benefits, despite requiring 40 % of the services (36). Recently, Brown et al proposed the adoption of a “Vision Zero” policy promoting the ideal of zero catastrophic injuries in rugby, however they concede that economic disparity makes health, and indeed injury prevention, very difficult in South Africa (42).

Protective Equipment

Compared to other collision sports such as American Football and Ice Hockey, rugby is played with minimal protection or padding. Protective equipment has been studied to determine whether it can reduce the incidence of injuries in rugby. Protective gear is proposed to limit injury, by reducing the force of impact and by softening the blow of direct trauma. If this proposed mechanism is true, then the tackle situation is the phase of play where the benefit should be seen. It has been hypothesised that players wearing protective equipment such as mouth guards, head gear and shoulder pads become greater risk takers on the field due to the perception of greater protection against injury when wearing this equipment (43). However, this has not been conclusively proven. Few studies have examined the association between catastrophic injuries and protective equipment. Fuller et al studied a cohort of 12 English Premiership clubs, over two seasons (44). This study showed there was no difference in the incidence of cervical and lumbar injuries between the players that wore head gear compared to the players that did not. There were no catastrophic injuries reported in this study (44).

No studies have looked at protective equipment and the outcome of catastrophic injuries, however, some studies have reported on protective equipment and the incidence of other injuries. As the mechanism of injury in head injuries, and concussion (mTBI) are similar to ASCI in the tackle situation, and up to 50 % of cervical spine injuries may in addition have a mTBI (ATLS), the literature on these injuries have been on protective equipment and head injuries, as similar trends may be possible.

Shoulder Pads

No studies have examined the effect of shoulder pads on catastrophic injury outcome. However, an *in vivo* study by Harris and Spears examined four different types of commercial shoulder pads and measured the peak force attenuation as well as time to peak impact (45). All pads reduced peak impact force and increased time to peak impact. But at higher forces, similar to the magnitude experienced in a game situation, there was a "bottoming out" of this force reduction. Thus, the shoulder pads would realistically offer little protection in a game situation. In another study of the tackle situation, peak force over the acromio-clavicular joint reduced by to 41 % in players wearing shoulder pads (46). This force reduction is not shown outside of the contact point and in the case of tackle-related ASCI, it would not be expected to reduce the deceleration of the neck, and thus not affect ASCI incidence. This coupled with the personal observation that many ASCI's in the tackled player are due to indirect, acceleration-deceleration forces, may explain why there is no measured relationship between shoulder pads and outcome.

Mouth Guards

Similarly, the relationship between mouth guard use and the incidence of catastrophic injuries has not been reported. Studies show that mouth guards do not consistently reduce injury risk (47). However, these conclusions might be affected by the reported non-compliance in studies on mouth guard use (48). Reasons that rugby players in Italy did not wear mouth guards were, poor fit, disruption of speech and air flow were reasons (48).

In contrast, Quarrie showed there was a self-reported reduction in dental and mouth injuries in players who wore mouth guards. In New Zealand in 1997, through a "domestic law safety variation" the use of mouth guards in under-19 age group rugby became compulsory. Self-reported rate of mouth guard use was 67 % of player weeks in 1993 and this increased to 93 % of player weeks in 2003. Across this period, there was a 43 % reduction in dental claims (49). Moreover, minor traumatic brain injuries (mTBI) incidence was reported to be halved when mouth guards were worn (50). In this study Hollis et al., followed 3000 male non-professional rugby players over one season. Trained injury recorders measured mouth guard usage and concussion data. Their conclusion was that those players that did not wear mouth guards were nearly twice as likely to have a concussion compared to players who wore mouth guards. .

Head gear

The same study by Hollis et al. (50) showed similar results between the use of head gear and its association with concussion. In this study, players that did not wear head gear were nearly twice as likely to suffer from a concussion compared to players who wore head gear. These results have been questioned by Navarro and colleagues as the use of protective equipment was self-reported and not randomised. In addition, the data collectors were not medically trained, and did not have access to the medical staff of the clubs. Finally, there was overlap of the confidence intervals of the two groups, which raises concern about the findings (47). These many methodological limitations have questioned the value of wearing protective equipment. Based on these studies it is premature to make conclusive recommendations about preventing mTBI by wearing a mouth guard or head gear. This further supports the notion that it is unlikely that mouth guard usage will prevent a catastrophic injury.

In a randomised control study in 82 rugby clubs over two seasons, McIntosh et al., compared the incidence of concussion and head injury in junior Australian rugby. Players were randomised into three groups. A control group, a head gear group and a modified head gear group. There was poor compliance in the head gear group (Normal and Modified); only 46 % of the normal head gear group wore their head gear. There was no difference in the concussion or head injury rates in this study and they concluded that no recommendation for the routine or mandatory use of head gear could be made in rugby (51).

Immobilisation post-injury

Cervical collars are considered paramount in modern prehospital trauma care (52). Cervical collars feature prominently in the Advanced Trauma Life Support (ATLS) guidelines from the American College of Surgeons (ACS) (53), and in the Prehospital Trauma Life Support (PHTLS) guidelines from the National Association of Emergency Medical Technicians (NAEMT) (54). In addition, cervical immobilisation including rigid collar application is recommended in the American Association for Neurological Surgeons (AANS) (55) and the Congress of Neurological Surgeons (CNS) Joint Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injury (55). The Joint Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injury provide 112 evidence-based diagnostic and treatment recommendations in the prehospital setting. ATLS and PHTLS are implemented in 50-60 countries in the world in the field of prehospital trauma care, including South Africa. World Rugby guidelines, specifically, the Level 2 Immediate Care in Rugby (ICIR) certification, use guidelines that are strongly influenced by the ATLS and PHTLS guidelines (53).

The rationale of immobilisation is to prevent movement in an unstable injury that may worsen neurological outcome. Immobilisation is regarded as safe, even when the person managing the patient is inexperienced, and should be applied until further assessment and imaging can take place. However, most of the patients to whom these ATLS and PHTLS guidelines are applicable, are not young sportspersons. They are older and the commonest cause of ASCI are falls (60 %) and motor vehicle accidents (21 %) (52); the data on sports-related ASCI is scarce (56). In these guidelines, the preferred method of immobilisation recommended is the combination of a rigid collar and supportive blocks on a spine board with straps (level III evidence). Worldwide, the ATLS guidelines have changed the way pre-hospital cervical spine injuries are managed. These guidelines provide evidence-based protocols for management of acute spinal injuries. Although the level of evidence is mostly level III, guidelines limit medico legal liability; and are effective in providing standardized management. Immobilisation is also regarded as safe and provides a visible, uniform mnemonic for less experienced or trained pre-hospital staff to follow (52). However, there is little research or evidence indicating an improvement in patient outcome when these techniques are used.

Up to 50% of cervical spine injuries (SCI) will also have a Traumatic Brain Injury (TBI) or concussion (56) (53). The incidence of TBI is higher in children than in adults (57). In the treatment of a TBI injury, the cornerstone is to reduce swelling and decrease intracranial pressure. A rigid cervical collar may increase intra cranial pressure by an average of 4.5 mmHg (58). This may negatively affect TBI outcome. In addition, a rigid cervical collar may complicate intubation and airway management, increase aspiration and respiratory restriction. It has also been proposed that the pre-hospital emergency staff may be inhibited in their management of other injuries if a trauma patient wears a rigid collar (52). In another study, there was increased mortality among patients with a Glasgow Coma Scale (GCS) score < 9, the typical cut-off for severe TBI, when treated by ambulance crews with advanced life support (ALS) training (59). The study did not determine whether this mortality increase was the result of their advanced pre-hospital interventions, including rigid collar and immobilisation, coupled with inadequate airway management and/or transport delays to hospital (59).

Although immobilisation and specifically spinal collars are currently recommended for ASCI, there is insufficient high level evidence supporting the current, recommended guidelines regarding patient outcome. Outside of these guidelines there is a growing body of evidence, often from developing countries such as Malaysia (52), where spinal injury is managed by practicalities rather than best practice that the application of a cervical collar may not be necessary and it has been proposed that it may even negatively affect outcome in ASCI. (52)

The need for immobilisation should be evaluated on a case-by-case basis by experienced pre-hospital personnel (60, 61). Specifically, there should be no immobilization in the coherently communicating, conscious, non-intoxicated patients, if they have no neck pain or tenderness. Cervical spine clearance in conscious and alert patients is better documented than in unconscious or obtunded patients. Several clinical approaches are available in the alert patient to assess whether they have a significant cervical spine injury and thus need radiological examinations and/or specific treatment. The Canadian C-spine Rule (CCR) is one of the best validated algorithms for radiography in alert and stable patients (61). The procedure was originally published in 2001 as a tool to decide whether patients require radiology in the hospital setting (61). In 2011, a revised edition was published for the prehospital setting, but now is used as a tool to decide whether patients require cervical spine immobilisation or not (62).

In summary, the ATLS guidelines have changed how ambulance crews and hospital staff manage trauma patients. But there is a paucity of high level evidence to support a real benefit on patient outcome. There is also very little level 1 evidence to support the currently recommended immobilization routines with regard to mortality, neurological injury, or spinal stability. More specifically in sport, no studies have looked at the outcome of ASCI regarding immobilisation practices and pre-hospital management. Despite the absence of level 1 research (I.e. evidence from a systematic review of all relevant randomized controlled trials) on the benefits of immobilisation after injury, early immobilisation, is still recommended and practiced.

Time to Definitive Treatment

The literature on the optimal time frame for the management of acute spinal cord injuries in sport is sparse. Many of the recommendations regarding optimal time for referral and transport are based on papers that discuss optimal surgical and medical management (63). It is recommended that an ASCI is transported to an appropriate spinal unit with specialist expertise within 4-6 hours (64). This has been referred to as the “4-hour golden window”

(63). However, this recommendation is not based on clinical trials. The 4-hour golden window appears to have come from Newton's 2012 paper in the British Journal of Bone and Joint surgery where he concludes "*In order to prevent permanent neurological damage after rugby injuries, cervical facet joint dislocations should probably be reduced within 4 hours of injury*" (63). This study followed 57 patients with rugby related ASCI due to facet joint dislocation who were admitted to Conradie hospital, in the Western Cape between 1988 and 2000. Thirty-two players were completely paralysed. Eight players were reduced within four hours and five of these players made full recoveries with no permanent neurological fallout. Twenty-four players were only relocated after more than four hours. None of these players made full recoveries. Only one player made a partial recovery. Based on these results Newton concluded that acute facet joint dislocations in rugby should be reduced within four hours of injury (63). These results supported the concept of an optimal window of treatment for the relocation of facet joint dislocation in ASCI in rugby players. Other studies that may have supported the concept of an optimal treatment window in ASCI are related to medical and surgical management of various clinical sub categories within ASCI's. For example, Bracken et al proposed that high dose IV corticosteroids within the first eight hours since ASCI injury improved outcome (65). Subsequent studies have indicated no or little benefit with significant morbidity. Therefore, the use of high dose corticosteroids to reduce swelling and secondary fallout is not a preferred treatment. The little or no benefit shown with early (< 8 hours) administration of corticosteroids (65) further weakens the rationale and support behind the 4-6-hour optimal window with regards to non-surgical management. In addition, the literature is scanty when looking at the optimal time for open reduction and surgical decompression and closed reduction with traction.

A study of South African rugby players who had an ASCI and complete records (n = 183) showed that 49 % of players that had an ASCI, waited more than six hours before receiving definitive treatment (39). There was 8 % mortality and 61 % permanent outcome in this group. This suggests a delay in treatment may be a contributing factor to outcome, together with other management factors. The results and outcomes reported may have shown a stronger association between delay in treatment and outcome as actual mortality levels in the cohort of 264 catastrophic injuries identified was closer to 23 % as 48 fatalities had incomplete records excluded from analysis (48 / 69).

La Rosa and Fehlings conducted two review studies on the timing of intervention in ASCI. La Rosa concluded that when open decompression was performed within 24 hours from ASCI, the neurological outcome was better than when open decompression was performed after 24 hours (66). Fehlings, however identified many papers that did not show a relationship between timing of open surgical decompression and outcome (67). Both La Rosa and Fehlings concluded these literature review, that early decompression is the only practice option. Early closed reduction (within 6-10 hours) of facet joint dislocation through traction has been shown to improve outcome in ASCI (68), however, there are few randomised, clinical trials that show closed reduction improves neurological outcome. In a prospective study on 24 patients, Cotler et al showed that early, closed reduction through traction showed no neurological deterioration, and thus its practice clinically is still supported (68). Fehlings concludes, based on the available literature, that urgent reduction of bilateral locked facets in a patient with incomplete neurological status could be supported. The BokSmart guidelines (64) and expert opinion in South Africa (69) support early reduction of dislocated cervical facets in a rugby player.

However, each patient needs to be treated on a case-by-case basis to ensure optimal outcome with minimal surgical risk. For example, where a patient is medically unstable, as in a high cervical lesion where they are autonomically unstable, management should be delayed for the physiological situation to stabilise. The risk of early decompression may outweigh the risk of a delay in surgery. Surgery in acute traumatic cervical injury, when performed in less than 72 hours from time of injury was associated with less in-hospital complications (70). In addition, there were lower hospital costs and shorter hospital stays, compared to injuries operated on after 72 hours. There were no differences in clinical outcomes and no increase in morbidity with this management (70).

In summary, data supporting the importance of timing of the treatment after injury is unclear. The “golden 4-hour window” for removal and transport to specialized care following ACSI is not supported consistently in the literature; in particular, when the initial pathology is not a facet joint dislocation but rather one of the other clinical diagnoses related to ASCI. Despite research being inconclusive about the timing of treatment after injury, early definitive management is still recommended. The use of early, high dose corticosteroids, that promoted the 4-6-hour window as the optimal time for definitive management, are no longer in practice, and no longer support the need for the 4-hour window until definitive treatment. However, in cases where there is facet joint dislocation or surgical decompression required it is recommended that decompression in under 24 hours is the only practice option. There remain many unanswered questions about management of ASCI in the acute phase of the injury

There is lack of data on the outcome and management of catastrophic injuries associated with rugby. Although the burden of ASCI and their implications was recognised in the 1970's, there has been a significant delay in the publication of accurate epidemiological studies, as most of these national databases were only established in the last ten years. However, it is generally accepted that the outcome of catastrophic injuries is determined by the primary insult to the spinal cord and not the secondary chemical cascade post injury. Therefore, it stands to reason that the way to reduce ASCI is primarily through prevention and not primarily through management (64). There are no studies on the immediate post injury management and outcome, even though there are recommended protocols and management certification mandated by World Rugby for these injuries.

Chapter 3

Immediate post catastrophic injury management in rugby. Does it affect Outcome?

Since 2008, BokSmart has prospectively recorded catastrophic injury data in a centrally controlled database. Catastrophic injuries were defined by SARU as:

"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 centre".

This definition included Acute Spinal Cord Injuries (ASCI); Traumatic Brain Injuries (TBI) and Cardiovascular events (Cardiac).

Injuries incurred during rugby training or matches are reported through the national Spineline emergency number, via hospitals and medical practitioners and rugby union administrators in both amateur and professional rugby. Data on the period before, during and after the injury incident were recorded using a detailed questionnaire of 72 questions (Appendix A). Any factor associated with reducing or modifying catastrophic injuries was documented in the catastrophic injury questionnaire. Factors associated with improving outcome were assessed. These included protective equipment, qualification of first responder, time taken to get patient to definitive care, and emergency equipment used.

Responses to the questions were sourced by the BokSmart Serious Injury Case manager (SICM) after consulting the injured player and/or their family. There is an incentive to report these injuries as the Chris Burger / Petro Jackson Players Fund (CBPJPF) provides financial assistance to injured players where possible (7). Despite all the information about the circumstance associated with the injury, there are no data on how these factors may be related to the outcome of the injury.

Aim & Objectives:

The first aim of the study was to determine whether the BokSmart programme's safety and educational components on "safety in the playing environment" and "emergency action plans", were applied following a serious injury. The second aim was to determine any associations between the outcome of a catastrophic injury and factors associated with the injury. The following questions will be answered;

1. Has the BokSmart serious injury protocol been followed when catastrophic injuries have occurred?
2. Are there demographic factors which affect outcome in catastrophic injuries?
3. Which management and/or safety factors are associated with a better outcome?
4. Is the wearing of protective equipment associated with better outcome?
5. Is on-field management of catastrophic injuries associated with better outcome?
6. Is full immobilization associated with better outcomes
7. Is a delay in transport to hospital associated with worse outcome?
8. Is a delay in definitive treatment associated with worse outcome?
9. Is management and outcome affected by expertise at the side of the field?
10. Does BokSmart target the correct personnel?

Materials and Methods

In total, 87 catastrophic injuries were reported to BokSmart between 2008 and 2014 and recorded in a centrally controlled database.

Following injury, the responses to the questions about the injury were sourced by the BokSmart Serious Injury Case manager (SICM) who consulted with the injured player and/or their family. There is an incentive to report these injuries as the CBPJPF provides financial assistance to injured players where possible (7). Thus, there is minimal chance that any catastrophic injuries were missed in South Africa (7).

The questions and categorization in the questionnaire were derived from information BokSmart provided from literature regarding safety in the environment (15).. An example of this is question 35 in the BokSmart Serious Injury follow up questionnaire, where the categorization of ideal time to definitive management is defined as less than 4 hours. This is consistent with the recommendations published in their BokSmart Safety in the Playing Environment document (15) and the BokSmart 4-6-hour window of treatment in ASCI (64). In addition, these questions considered the epidemiological information World Rugby required for each catastrophic injury. Any factor associated with reducing or modifying catastrophic injuries was documented in the catastrophic injury questionnaire. Factors associated with improving outcome such as protective equipment, qualification of first responder, time taken to get patient to definitive care, and emergency equipment used were assessed.

"Optimal treatment" was a composite variable that was created from questions associated with the BokSmart Safety in the Playing Environment (Tables 3. 11 and Appendix B Tables: 6 - 9). This included that; (i) the first responder was medically trained; (ii) medical management started on the pitch; (iii) optimal stabilization of neck was provided; (iv) transport was by ambulance or specialist care; (v) there was less than one-hour delay before hospitalization; and (vi) Spineline was contacted.

Theoretically, protective gear, including headgear, mouth guards and shoulder pads should provide some benefit in the phase of rugby where there is significant contact and deceleration. However, because of the small numbers, protective gear was assessed as a preventative measure of ASCI in the tackle situation only (i.e. only the player making a tackle).

Eighty-seven catastrophic injuries were reported to BokSmart between 2008 and 2014. These injuries included all catastrophic injuries sustained in professional and amateur rugby in South Africa. All ASCI injuries were further classified on outcome at one-month post injury diagnosis, either as permanent or non-permanent (Figure 1). Non-permanent, included near misses; catastrophic injuries that on hospital diagnosis, one-month post injury had fully recovered. Permanent outcomes were divided into fatal, quadriplegia and neurological deficit. For this study, various factors that were purported to have affected the outcome of injury, were compared with the one-month hospital determined outcome of ASCI (fatal, quadriplegia, etc.)

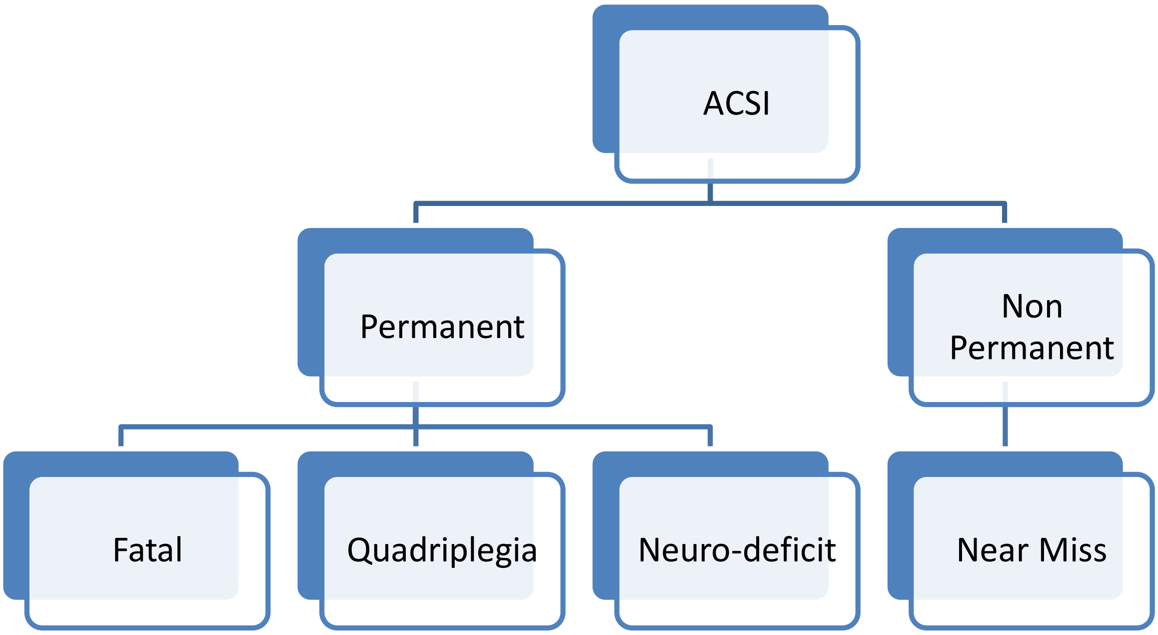

Figure 1: Organogram of ACSI outcomes

Permission to analyse the CBPJPF/SARU database was granted by the University of Cape Town's Human Research Ethics Committee (ERC 438/2011). In addition, SARU/CBPJPF provided the authors with permission to access the database.

Statistics

Data are presented as proportional percentages relating to permanent vs. non-permanent outcomes. The "not provided" (i.e. missing information) and not applicable categories were also excluded when calculating percentage to ensure the data are comparable between variables. Frequencies are presented based on the categorical nature of the data: injury outcome and risk factor. As a result of the relatively small sample sizes in each category (< 10 in general), a Chi squared Fishers Exact test was used to compare differences in injury outcome and risk factors. A 95 % confidence level was accepted for statistical significance ($p<0.05$).

All analyses were performed using Stata 12.1 (Statacorp 2014. Stata Statistical Software: release 12; StataCorp LP, College Station, Texas, USA.)

Results

Between 2008 and 2014, there were 87 catastrophic injuries reported in South African rugby including junior and senior rugby of all levels. Of these 87 events, 69 (79 %) were acute spinal cord injuries (ASCIs), 11 (13 %) were traumatic brain injuries (TBIs) and the remaining seven (8 %) were cardiac events (Table 1).

ASCIs were the most frequent type of catastrophic injury among both junior (72 %) and senior (84 %) players. More junior players (20 %, n=7) had TBIs compared to senior players (8 %, n=4). Cardiac events were equally infrequent in both age categories (8 % for both junior and seniors).

Table 1: Types of catastrophic injuries (n = 87) recorded in South African rugby from 2008 to 2014

	ASCI	TBI	Cardiac
Junior (n=36)	72% (n=26)	20% (n=7)	8% (n=3)
Senior (n=51)	84% (n=43)	8% (n=4)	8% (n=4)
Total (n=87)	**79% (n=69)**	**13% (n=11)**	**8% (n=7)**

ASCI – Acute Spinal Cord Injury, TBI – Traumatic Brain Injury

Subsequent analyses will focus on the 69 ASCI reported from 2008 to 2014. We have excluded the cardiovascular events (n = 7), as they are not a specific risk associated with the game of Rugby Union. This decision was also adopted in other studies that used these data (7). Traumatic brain injuries were also excluded owing to their small numbers (n = 11). The outcome of the ASCI was categorised in order of increasing severity into non-permanent and permanent outcomes (Figure 1).

The majority (55 %) of rugby-related ASCIs in South Africa between 2008 and 2014 had a permanent (fatal, quadriplegia, or neurological deficit) outcome, while a further 45 % suffered near misses with no permanent neurological deficit sustained (Table 2).

Table 2: Number of players who sustained an acute spinal cord injury (ASCI) and their outcome

	Outcome of ASCI		
	Non-permanent	Permanent	*Not provided*
Total no. of injuries	**45% (n=30)**	**55% (n=37)**	***(n=2)***

The commonest event associated with ASCI was the tackle with 46 % (n=32) followed by 32 % of the injuries being associated with the scrum (n=23). In the tackle, 52 % (n=16) involved the ball carrier and 48 % (n=15) the tackler. There was one tackle situation where the information of ball carrier or tackler was registered as unclear ("not provided"). The ruck phase was the third largest contributor to ASCI, accounting for 16 % (n=11).

In terms of ASCI outcome, the scrum was associated with the highest proportion of permanent outcomes (73 %, n=16), while the tackle had an almost equal distribution between permanent and non-permanent outcomes. In contrast with the scrum, most ruck injuries were associated with a non-permanent outcome. (Table 3)

Table 3: Event causing ACSI injury

	Not provided	Non-Permanent	Permanent	**Total**
Tackle	*(n=1)*	52% (n=16)	48% (n=15)	46% (n=31)
Tackler	*0*	47% (n=7)	53% (n=8)	48% (n=15)
Ball carrier	*0*	56% (n=9)	44% (n=7)	52% (n=16)
Scrum	*(n=1)*	27% (n=6)	73% (n=16)	34% (n=22)
Ruck	*0*	73% (n=8)	27% (n=3)	16% (n=11)
Collision	*0*	0	100% (n=1)	1% (n=1)
Unclear	*0*	0	100% (n=2)	3% (n=2)
Total	***2***	**30**	**37**	**69**

Fifty-two % of all ASCIs were in players of colour (n=36). When comparing outcomes by ethnicity, Black Africans had the highest proportion of permanent outcomes from ASCIs to (86 %, n=12) in comparison to non-permanent outcomes. To facilitate statistical comparison of outcomes by ethnicity, injuries to Black African, Mixed Ancestry and Indian players were grouped as 'Colour'. With this grouping, players of colour were 2.4 times more likely ($p<0.001$) to be associated with a permanent outcome (fatal, quadriplegia or neurological deficit) than White players (Table 4).

Table 4: Ethnicity of players who sustained an acute spinal cord injury (ASCI) and their outcome (p=0.001 for Colour – Black African, Mixed Ancestry and Indian – vs. Non-colour -White)

	Not provided	Non-Permanent	Permanent
Colour	*0%*	25% (n=9)	75% (n=27)
Black African	*0%*	14% (n=2)	86% (n=12)
Coloured/Mixed Ancestry	*0%*	32% (n=7)	68% (n=15)
Indian	*0%*	0%	0%
White	*0%*	69% (n=20)	31% (n=9)
Not provided	*(n=2)*	*(n=1)*	*(n=1)*
Total	***2***	**30**	**37**

Protective gear

Seven players (25 %) were wearing headgear when injured in the tackle. Of those who were wearing headgear, 71 % (n=5) sustained a permanent ASCI. In comparison, 43 % (n=9) of those players who were not wearing headgear had the same permanent ASCI outcome. However, the proportion of permanent outcome was not significantly different (p=0.385) between players who were or were not wearing headgear at the time of their injury.

Table 5: Proportion of players wearing headgear who sustained an acute spinal cord injury (ASCI) in the tackle situation.

	Not provided	**Non- Permanent**	**Permanent (%)**
Wearing Headgear	*0%*	29% (n=2)	71% (n=5)
No headgear	*0%*	57% (n=12)	43% (n=9)
Not provided	*(n=1)*	*(n=2)*	*(n=1)*
Total	**3% (n=1)**	**50% (n=16)**	**47% (n=15)**

Similarly, wearing shoulder pads was not associated with ASCI outcome (p=0.601) (Table 6). Thirty-five players (52 %) were wearing shoulder pads when they were injured. Fifty-two % (n=19) of players wearing shoulder pads had a permanent ASCI outcome, while 55 % (n=12) who were not wearing shoulder pads had the same outcome.

Table 6: Proportion of players wearing shoulder pads who sustained an acute spinal cord injury in the tackle situation (ASCI)

	Not provided **(%)**	**Non- Permanent**	**Permanent**
Wearing shoulder pads	*0%*	48% (n=16)	52% (n=19)
No shoulder pads	*0%*	45% (n=10)	55% (n=12)
Not provided	*(n=2)*	*(n=4)*	*(n=6)*
Total	***(n=2)***	**45% (n=30)**	**55% (n=37)**

Fifty % (n = 13) of players injured in the tackle were wearing a mouth guard at the time of the injury (Table 7). Wearing a mouth guard was also not associated with ACSI outcome (p=0.500) (Table 7). While, 47 % (n=6) of players wearing a mouth guard had a permanent outcome, 53 % (n=7) of those that weren't wearing a mouth guard had the same outcome.

Table 7: Proportion of players wearing mouth guards who sustained an acute spinal cord injury during the tackle situation (ASCI)

	Not provided	**Not Permanent**	**Permanent (%)**
Wearing mouth guard	*0%*	53% (n=7)	47% (n=6)
No mouth guard	*0%*	47% (n=6)	53% (n=7)
Not provided	*(n=3)*	*(n=2)*	*(n=1)*
Total	***93% (n=3)***	**47% (n=15)**	**44% (n=14)**

Mode of Transport

The majority (79 %; n=49) of players were transported to hospital via ambulance. A further 21 % (n=12) were transported via car, and the remaining one by air transport. Fifty-nine % (n=29) of players transported by ambulance had a permanent outcome with 41 % (n=20) having a non-permanent outcome reported. Players transported by car had a permanent outcome in 33 % (n=4) of cases, and non-permanent in 67 % (n=8) cases. However, the difference in outcome proportions between ambulance and car transport was not significantly different (p=0.099).

Table 8: Mode of transport to hospital for players who sustained an acute spinal cord injury (ASCI)

	Not provided	**Not Permanent**	**Permanent (%)**
Ambulance	*0%*	41% (n=20)	59% (n=29)
Car	*0%*	67% (n=8)	33% (n=4)
Helicopter	*0%*	100% (n=1)	0%
Not applicable	*0%*	0%	100% (n=1) *
Not provided	*(n=2)*	*(n=1)*	*(n=3)*
Total	**3% (n=2)**	**43% (n=30)**	**54% (n=37)**

**Fatal ASCI in Schoolboy at training session. Death prior to transport.*

Post injury management

Overall, the majority - 63 % (n=22) - of players were transported "immediately" to hospital (Table 9). It is important to note that "immediate" was the subjective perception of the person who completed the BokSmart serious injury follow-up questionnaire (Appendix I- question 35). Of those players transported immediately, 45 % (n=10) had non-permanent outcomes and 55 % (n=12) had permanent outcomes. The players who were not transported to hospital immediately had a marginally higher percentage of non-permanent outcomes (62 %; n=8) than those who were 45 % (n=10). However, this difference in outcome was not statistically significant (p=0.285) (Table 9). Thirty-two respondents did not provide an answer to this question.

Table 9: Number of players taken "immediately" (subjective perception) to hospital who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	45% (n=10)	55% (n=12)
No	*0%*	62% (n=8)	38% (n=5)
Not provided	*(n=2)*	*(n=12)*	*(n=20)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

Only 32 respondents answered the questions about receiving oxygen by mask during emergency treatment (Table 10). Of these 32, only eight (25 %) indicated that the injured had received oxygen by mask during emergency treatment. Of those who received oxygen, 37 % (n=3) had a non-permanent outcome and 63 % (n=5) had a permanent outcome. However, these proportions were not significantly different among players who did not receive oxygen after the injury (p=0.343).

Table 10: Oxygen used for players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	37% (n=3)	63% (n=5)
No	*0%*	54% (n=13)	46% (n=11)
Not applicable	*0%*	100% (n=3)	0%
Not provided	*(n=2)*	*(n=11)*	*(n=21)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

Optimal immobilisation when the player was removed from the field following an ASCI was achieved with different modalities. For example, the player could be immobilised on a spinal board or stretcher; with a rigid neck brace; head blocks and a spider harness to secure the player tightly to the stretcher or spinal board. "Optimal treatment" was a composite variable created from these modalities presented (Appendix B: Tables 1-5) and was defined as having 4 or 5 of those procedures in place.

Thirty-three players (50 %) had optimal immobilisation with either 4 or 5 of the immobilisation modalities reported as being provided (Table 11). Of these with "optimal immobilisation", 48 % (n=16) had a non-permanent outcome recorded and 52 % (n=17) a permanent outcome recorded. Players who had non-optimal treatment had a slightly higher permanent outcome (58 %) although this difference was not significant (p=0.049). Forty-seven % of players with no immobilisation had permanent outcomes (n=7). (Table 11)

Table 11: Optimal immobilisation in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Optimal stabilization (4-5)	*0%*	48%(n=16)	52% (n=17)
Non-optimal	*0%*	42% (n=14)	58% (n=19)
Sub Optimal (3)	*0%*	33% (n=4)	67% (n=8)
Poor (1 -2)	*0%*	33% (n=2)	67% (n=4)
No Stabilization	0%	53% (n=8)	47% (n=7)
Not Provided	*0%*	*(n=1)*	*(n=2)*
Total	***0%***	**43% (n=31)**	**57% (n=38)**

Forty-six % (n=32) of injured players were regarded as having had "Optimal treatment", that followed principles of best current practice (Table 12) (see 'Materials and Methods' section for definition of Optimal treament0, A further 24 % (n=16) were regarded as having sub optimal (3-4) treatment and stabilization. Thirty % (n=21) had treatment that was poor or incorrect (0-2) and did not follow best practice. In those patients that were regarded as having optimal treatment there was no significant difference in outcome, with 47 % (n=15) having a non-permanent outcome or near miss, and 53 % (n=17) having a permanent outcome or deficit. In those injured players that had non-optimal treatment (sub-optimal plus poor treatment), there was no significant increase (p=0.560) in permanent outcome vs. those injured players that received optimal treatment 54 % (n=19). In the sub–optimal treatment group there was a slight increase in permanent outcomes vs. optimal outcome with 62 % (n=10) compared to non-permanent outcomes 38 % (n=6), although this was not statistically significant (p=0.380) (Table 12).

Table 12: Optimal treatment in players who sustained an ASCI (First responder was medically trained; medical management started on pitch; optimal stabilization of neck; transported by ambulance or specialist care; <1 hour wait before hospitalization; Spineline contacted)

	Not Provided	Non-Permanent	Permanent (%)
Optimal treatment (5-6)	*0%*	47%(n=15)	53% (n=17)
Non- Optimal (0-4)	*(n=2)*	46% (n=16)	54% (n=19)
Sub Optimal (3-4)	*0%*	38% (n=6)	62% (n=10)
Poor (0-2)	*(n=2)*	53% (n=10)	47% (n=9)
Total	***3% (n=2)***	**45% (n=31)**	**52% (n=36)**

Discussion

The main finding of this study was that no factors in the immediate post injury management of catastrophic injuries were associated with ASCI outcome. Specifically, this study showed that initial on field management, immobilisation, transport, and time to definitive treatment were not significantly associated with the long-term outcome of an ASCI. In addition, a novel finding was that the use of protective equipment showed no influence on the outcome of ASCI in the tackle situation. Of the factors investigated, only ethnicity - a proxy for socio-economic status within South Africa - was significantly associated with ASCI outcome (36). This finding is consistent with other studies evaluating different components of the BokSmart programme and may reflect issues outside the scope of rugby (33).

Despite 87 catastrophic injuries being recorded between 2008 and 2014 in rugby played across all ages in South Africa, there were no clear associations between outcome and acute injury management. Most of these catastrophic injuries were ASCI (n=69). These absolute numbers are higher than in France (4), Argentina (29), and the United Kingdom over similar periods. However, a comparison between countries should be interpreted with caution. Firstly there more players in South Africa than in France and Argentina (40). Secondly, a higher proportion of catastrophic injuries might have been reported in South Africa due to potential financial incentive from the CBPJF, as argued previously. The BokSmart database is the only database that has measured near misses as well as disabling catastrophic injuries in the database. The decision to do this was to get a clearer picture of the burden of ASCI in rugby.

In the Senior age group ASCI were the largest contributor to mortality and morbidity with 84 % of catastrophic injuries. Traumatic Brain Injury was the second most common catastrophic injury (13 %; n=11). In the Junior age group, there was a higher percentage of TBI (20 % vs. 8 % in Senior age group). This is similar to The BokSmart data from 2008 to 2011 where Junior age groups have a higher incidence of TBI's compared to Senior age groups (33). Of the 67 catastrophic injuries as a result of ASCI (data not provided in 2 cases), 45 % had a non-permanent outcome and 55 % a permanent outcome. The tackle situation was the phase associated with the highest number of ASCIs (46 %); the ball carrier being involved in 52 % of the incidents while the tackler was involved 48 % of the time. Tackle details were not provided for one player. This is consistent with unpublished data on injuries in the 2015 Currie Cup and 2015 Super Rugby, where the ball carrier, and the tackle situation is now the most associated with injuries (Lindsay Starling, unpublished data; Professor Martin Schwellnus, unpublished data).

Forty-eight % of ASCI in the tackle situation had a permanent outcome. The scrum accounted for 34 % of ASCI, but was associated with the highest proportion of permanent outcome (73 %). These results differed from those reported in the review of Rugby Union injuries to the cervical spine and spinal cord (71). This review shows the scrum remained the most common phase of ASCI and the phase with the highest number of permanent outcomes. Within this review study however, various studies (8, 2) also showed the tackle was the most common phase associated with the most ASCI's. There are other studies published recently, where the tackle, has overtaken the scrum as the phase of play associated with the most catastrophic injuries (25). These studies support our findings of the tackle phase now being the highest phase associated with ASCI, but the scrum remains the phase with the highest number of permanent outcomes (8, 29, 4). The reduction in the incidence of scrum related ASCI may be due to the changes in scrum laws, specifically in junior and amateur rugby (3). Both Shelly (between 1994 and 2005), and Kew (between 1963 and 1989)have also shown backs have a higher incidence of ASCI compared to forwards; this is consistent with the tackle phase now becoming the phase most at risk (9, 8).

Optimal Management

The BokSmart programme is an education based programme that provides online, written and course based education to referees, coaches and the public on safety in rugby. One of the materials provided is the BokSmart Safety in the Playing Environment (15) which details the optimal requirements for a rugby match to take place in safety. Optimal treatment was defined as being consistent with the recommendations in the BokSmart Safety in the Playing Environment document described earlier.

By this definition, 50 % of the ASCI recorded had optimal treatment, and a further 27 % had some form of immobilisation - even though regarded as sub-optimal. Compared to the data in the study by Hermanus et al (2010) collected between 1980 to 2007, there has been a large improvement in medical management at rugby matches. In that study only 49 % had spinal immobilisation initiated on the field, and only 5 % had optimal immobilisation (39).

However, despite the improved treatment following an injury, there is much capacity to improve further as half of spinal injuries were managed sub-optimally. Although this optimal treatment composite score was not associated with outcome (p=0.380) it might be clinically relevant. This is supported in our results where there was 67 % (n=8) permanent outcome in the sub-optimal treatment group compared to 52 % (n=17) and 47 % (n=7) permanent outcome in the optimal and poor treatment groups respectively. This indicates that the long-term outcome is negatively affected in patients where the ASCI is not an obvious emergency, and the symptoms are not recognised as a serious neck injury. In such cases, all management principles to immobilise, transport and treat definitively within the 4-hour period were not provided.

Initial on Field management

Within the definition of optimal treatment, optimal on-field management included; time of first medical attention (on field vs. off field), on field responder status (medical vs. non-medical) and medical evacuation. There was no significant difference in outcome of ASCI recorded with any of the parameters measured within initial on field management. Eight-nine % of ASCI had management initiated on the pitch with 42 % of treatment initiated by a medically trained responder. Forty-six % were finally managed by a medically trained person, 51 % by a trained non-medical person and 3 % by a coach or spectator. There are no studies to compare these results to since the study of Hermanus et al. (39), where data were collected retrospectively on ASCI between 1980 and 2007. In Hermanus' study only 49 % of ASCI had immobilisation initiated on the field, and only 66 % had any on field management. Based on these changes it suggests the availability of medically trained personnel, and trained non-medical personnel at rugby matches has increased in South Africa and this may be due to the BokSmart programme, specifically their Rugby Medic programme where they provide a rugby medic programme to educate those involved in rugby in rural/remote areas. Between 2008 and 2016, 2 773 facilities, including 1 593 schools and 1 099 rugby clubs have offered courses training interested members as rugby medics. A total of 35 421 rugby medics were trained with most trained members being Black African (60 %) and of Mixed Ancestry (27 %) (Dr Viljoen, *personal email communication*). This suggests that there has been significant exposure within less resourced communities.

Immobilisation

Current clinical trauma recommendations include neck immobilisation as a critical component of immediate management, although this advice is under continuous review. Neither the application of head blocks, spider harness, spinal board/stretcher or neck brace were associated with a more positive outcome. In this study, the percentage of injuries where immobilisation was applied was higher (65 % had neck blocks, 55 % spider harness immobilisation, 70 % rigid neck brace applied and 70 % spinal board immobilisation) than in the study by Hermanus et al (2010). In that study, less than 50 % of injuries had a medic or medical equipment for immobilisation at the game where the ASCI was reported. This suggests that in most cases, compared to the period where data were collected (1980-2007) (39), equipment is more readily available. Also, some form of medically trained management was applied to suspected ASCI's, even though it was not associated with outcome. In addition, ASCI is now being recognised, and appropriate treatment instigated with optimal immobilisation being applied in 50 % of cases. Even though outcome is not significantly affected with 49 % still having a permanent outcome, it does indicate that the message BokSmart is promoting through the education of referees and coaches may be improving management in those players at risk.

Oxygen was used in the immediate management of only 25 % of players who sustained an ASCI. There was no significant difference in outcome between the players who did not have treatment oxygen compared to those players who did. The question about whether oxygen was given in the acute pre-hospital management was not answered in 51 % (n=34) cases. This suggests the questionnaire needs to be revised or this information needs to be collected differently to get accurate data.

Transportation

The mode and speed of transport to definitive care is regarded as influencing long term outcome of catastrophic injuries. In this regard, most players in this study were treated optimally with 80 % reporting treatment with the optimal 4-hour period; seventy-nine % being transported by ambulance or helicopter, and 63 % reporting that they had been transported "immediately" after the incident with no delays.

Although there was a higher percentage (41 %) of permanent outcome reported in those players transported via ambulance compared to those transported by car (31 %), this finding was not significant. The players transported by car could also have had less obvious clinical symptoms and signs that were not recognised initially. However, it is within this group, with unrecognised symptoms, that unstable injuries may deteriorate and the outcome be changed for the worse. Other studies have also suggested that education on the recognition of spinal injuries, will improve management and specifically neck immobilisation and appropriate transport (72). BokSmart, has addressed this by educating coaches and referees to recognise these injuries. However, further work may be required to ensure not only immediate recognition of the injury, but the actual management of the injury is optimal. The clear majority (90 %) of all ASCI were transported to hospital and received definitive care in less than 4 hours, with 55 % having a permanent outcome. Unexpectedly, immediate transport (transport <1 hour from injury) was not associated with a better outcome, with 55 % of those transported in <1 hour having a permanent outcome compared to 38 % permanent outcome in those transported after 1 hour. Four players (20 %) had a delay in treatment and received definitive treatment in more than 4 hours. This can be attributed to the seriousness of the injury not being apparent in three players, and transport was not available for one player. The only permanent outcome was in the player where there was no transport available. This again suggests that ASCI recognition is the greatest factor that determines appropriate and optimal management. There are no studies that look specifically at the management and outcome of ASCI in Rugby. However, indirect inferences can be made from a study conducted between 2002 and 2003 of rugby-related head, neck and face injuries in Australian youth (n=1 159 players) (72). This study recorded 554 head, face and neck injuries. Two of these injuries were ASCI related catastrophic injuries. In both cases, there was no specific management applied, as the players left the field with no neurological fallout; neither players were immobilised, and both were transported to hospital in private cars. However, no details of the outcome were included in that study and thus is it difficult to draw comparisons with the present study (72).

Spineline

After immediate on-field management and immobilisation, contact with Spineline is recommended to facilitate optimal treatment in ASCI in Rugby. In this study, only 45 % of cases reportedly contacted Spineline at the time of injury. Spineline was not contacted in 55 % of the ASCI cases reported. However, a further 11 patients did not indicate in the questionnaire whether Spineline was contacted (data not provided) and it may be assumed in these cases that Spineline was not contacted initially. If those that did not contact Spineline and those that did not answer the question were combined, then only 28 % of cases contacted Spineline at the time of the injury. This is of concern as this is a resource that has been in existence since 2008 and is well advertised through the BokSmart programme. Spineline contact is mentioned repeatedly during the BokSmart course to both referees and coaches. The two most common reasons for not contacting Spineline were not knowing the number, and not recognising the injury as a spinal injury. As the player or relative provided the information in the serious injury follow up questionnaire, and they are not trained by BokSmart, this may be misleading. But it does support the need to expose the Spineline number to the public and those managing these injuries. Of the 28 % who did contact Spineline, there was a higher but non-significant association with permanent ASCI outcome. However, as discussed previously, this could also be because the outcome was determined and obvious at the initial trauma. BokSmart and education regarding the Spineline is primarily aimed at coaches and referees. The BokSmart Serious injury protocol document states;" In *the event of a serious and/or catastrophic rugby injury, a person of authority should be identified at the club or school to immediately take charge of managing the situation. In the case of such an injury seniority should preside with a sports physician, medical doctor, emergency care personnel, physiotherapist, biokineticist, rugby medic, first aider, coach, referee, and manager **in that order**.*" This creates a hierarchy that if followed excludes the very people who are biennially exposed and trained to recognise ASCI's in the management of an emergency. This was shown in this study by the fact that no referees managed an ASCI and only 3 ASCI's had a coach involved in their management.

From a practical perspective, these results suggest that in the absence of medical personnel, coaches, and to a lesser extent referees should be encouraged to be the person of authority identified to initiate the process in the case of a serious and/or catastrophic injury. This approach should ensure that Spineline is contacted for information on management and stabilisation of the player.

Protective Gear

Protective gear is proposed to limit injury, by reducing the force of impact and by softening the blow of direct trauma. If this proposal is true, then the tackle situation is the phase of play in which the benefit should be seen. There were 32 ASCI in the tackle situation. Only 25 % (n=7) of the players were wearing head gear at the time of injury. However, 61 % of ASCI wore shoulder pads. This is significantly higher than in professional rugby (*Personal observation)* and may suggest that players in the lower tiers of rugby wear shoulder pads to protect their shoulders rather than strapping which is expensive and requires medical expertise to apply. The majority (52 %) of players who sustained an ASCI were wearing shoulder pads. However, there was no difference in outcome between players who wore shoulder pads compared to those that did not. These results are not entirely unexpected as in the tackle phase, the force on the ball carrier is an indirect, acceleration-deceleration injury, and this may explain why there is no measured relationship between shoulder pads and outcome. Of the players who were wearing shoulder pads, 52 % had a permanent outcome. Mouth guards were worn in only half of those ASCI reported in the tackle situation. Six cases did not provide data. Our study has shown that in the tackle situation there is no association between protective equipment and ASCI outcome when the players were wearing either a mouth guard, shoulder pads, head gear or a combination of all three. The benefit of protective gear in rugby in the prevention of catastrophic injuries has not been studied. Most studies examine the association between protective equipment and concussion or head and neck injuries (73, 51, 74). Most studies showed no association between protective equipment use and a reduction in injuries. One study on injuries in premier division clubs in England, showed there was no significant difference in cervical and head injuries in those players who wore head gear compared to those who did not (44).

As there is limited literature on catastrophic injuries and the association with protective equipment use, we have compared our results with studies looking at the association between protective equipment and concussion (mTBI) and head injuries. These injuries have a similar mechanism and associated head and spinal injuries are frequent. The ATLS guidelines state that 5% of patients with a TBI have an associated spinal injury, whereas 25% of patients with a spinal injury have at least a mild TBI (53). Thus, it may be inferred that if there is no benefit between protective equipment and concussion, it is likely that there will be no association between ASCI and protective equipment, as the force required for an ASCI is in general greater than the force for a concussion. Finch and colleagues have shown there may even be a negative effect of wearing protective gear in the incidence of traumatic injuries. This finding was attributed to the player's perception of having greater protection (43). Catastrophic injuries have not been studied in this context. However, the relatively high number of players who were wearing shoulder pads in our study and sustained a catastrophic injury tends to support the theory. It may be argued that conditioning and neck strength can be considered more important than protective equipment in the reduction of ASCI. This is based on the study of Hislop et al., (2017) that showed that a pre-movement control exercise programme reduced musculoskeletal and concussion related time loss injuries (> 24 hours) in youth rugby (75). Even though this reduction was in non-catastrophic injuries, it is proposed that rugby specific conditioning and movement control is important in the reduction of injuries and may apply to catastrophic injuries.

Ethnicity

In this study rugby players of Colour (i.e. Black African and Mixed Ancestry players) are 2.4 times (p=0.001) more likely than White players to suffer a permanent outcome in an acute spinal cord. Players of Colour make up 52 % of ASCI's. Black Africans had the highest permanent outcome percentage of all race groups (86 %) followed by Mixed Ancestry players (68 %). White players had a far lower percentage of permanent outcome (31 %). This is consistent with a previous study on the demographics of ASCI's in South African rugby across all age groups, where there was a significantly worse outcome recorded in Black players (39). Also, there was a relatively higher percentage of catastrophic injuries in the Black African players compared to their relative participation in rugby. The differences were attributed to the imbalances in health services and socioeconomic disparity. South Africa has been consistently regarded as the most inequitable country in the world (www.data.worldbank.org) with the Gini index being between 0.660 and 0.669 and widening annually. To contextualise this, a Gini index ranges between zero and one, where an index of zero expresses perfect equality, and an index of one expresses maximal inequality.

Socioeconomic status (SES) and access to basic social services are compounded by inequalities in the South African health services where the poorest quintile is reported to receive less than 10 % of health benefits, despite requiring 40 % of the services (36). There is still a large socio-economic disparity between race groups (36), and a significant difference in access to health services outside of the larger metropoles (64). SES remains a large factor in the risk of catastrophic injury as it affects stature (76), body morphology (relevant in rugby players) (38), training status, nutrition, education, and access to optimal immediate medical management. Studies on ethnicity and injury are sparse. Therefore, it is difficult to compare these data with data from other studies. The only other study was a review by Quarrie who reported on an increase in ASCIs in Fijian rugby players (71). The study could not determine whether the increase in the number of ASCIs in Fijian players was due to extrinsic factors or intrinsic factors attributed to ethnicity (71).

Recently, Brown et al proposed the adoption of a "Vision Zero" policy promoting the ideal of zero catastrophic injuries in rugby (42). However, the authors concede that economic disparity makes health, and indeed injury prevention, very difficult. In our study, there has been a large increase in the number of players that received optimal or some form of medical treatment irrespective of demographics compared to previous South African studies (39). But the significant finding of our study was that players of colour are 2.4 times more likely than white players to have a catastrophic injury with poor outcome. This finding occurred in the presence of improvements in on-field management, immobilization, transport and definitive care compared to previous South African studies (39). While rates of catastrophic injury among junior players have decreased (33), it is of concern that players of colour at senior level are still at a higher risk of a permanent ASCI than White players. Since the start of the 2013 season there have been changes in scrum laws at junior and amateur level resulting in a decrease in scrum related injuries (3). This has resulted in the tackle phase now being the most common phase for injury (7). Although permanent outcome numbers are less than in the scrum phase, it is conceivable that nutrition and conditioning of players at the senior level is more varied. Both these factors are influenced by SES. Also, the larger differential in body mass between the largest and the smallest player and ethnic groups (38), may be the single biggest reason for the demographic significance in catastrophic injuries.

Limitations

It is fortunate that catastrophic injuries are not common events in rugby. As a consequence, this study has a relatively small sample size, which may be viewed as a limitation. This is a reality of research in this area of study. Also, missing data impacts on the statistical power, and may be the reason why we found so few statistical associations with outcomes in immediate post catastrophic injury management. Another statistical weakness was the inclusion of multiple correlations. To address this, we set the significance level at $p<0.001$.

The dataset itself is a limitation as the definitions used for defining catastrophic injuries, as well as permanent or non-permanent outcomes were defined by the custodians of the programme itself. These definitions vary from other comparative studies in the literature, and this makes it difficult to compare BokSmart findings with other catastrophic injury studies that use alternative, internationally recognised definitions. It is recommended that the definition of catastrophic injuries in this dataset is reviewed, as well as the time at which final neurological outcome is assessed. Future research should ensure that definitions are consistent across all similar studies. In addition, the lack of standardised answers generated from the BokSmart serious injury questionnaire, and the number of questions where data were not provided or missing was also a limitation. Unfortunately, there were incomplete questions (up to 20 %) in the questionnaires, and therefore these data could not be analysed. The missing data may be due to delays in collecting data and poorer recall amongst patients and family members, but could also be due to the questionnaire itself. The question was in English and administered in English. Although there was a translator present, English is only the fourth most spoken home language in South Africa (77), and difficulties in translation may have effected data collection. Simplifying the questionnaire to cater for all demographics may improve data collection in the future.

Another limitation to the study is being unable to determine the reason behind specific management practices following an injury. Medical personnel were not interviewed, and those managing the injury were not interviewed. The information was obtained from the patient or the closest family member. Thus, in the case of transportation, injured players transported by car could also have been the players with less obvious clinical symptoms and signs that were not recognised initially. Permanent outcome patients may therefore have been treated very differently to those described above. It is within this group that that unstable injuries with unrecognised symptoms may deteriorate and the outcome be changed for the worse. In addition, certain questions may not be relevant to players. For example, education regarding Spineline is not taught to players, and thus their lack of knowledge may not be an indictment on the effectiveness of the BokSmart message but rather that the audience needs to change.

Chapter 4

Summary and conclusion

The main finding of the study was that none of the factors associated with immediate care in an ASCI were associated with outcome. Although this was unexpected, it may be explained by the fact that the prognosis is already determined by the initial insult. Indeed, some experts claim that the outcome of catastrophic injuries is determined primarily by the primary insult to the spinal cord and not the secondary physiological cascade post injury. Thus, these authors believe that the way to reduce ASCI is prevention and not management (69). To our knowledge, this is the first study that has examined the association between immediate post catastrophic injury management and outcome. Another potential explanation for the lack of associations was the relatively small sample size. Despite the small sample size this is one of more comprehensive studies (n=69 ASCI) conducted to date.

Three different clinical scenarios may explain the lack of association between management after the injury and clinical outcome. The first scenario is a true catastrophic injury where the severity and clinical signs are obvious at presentation. In these patients, the outcome is most likely already determined and all optimal treatment components are applied owing to recognition of the injury as an ASCI. Thus, despite optimal treatment and rapid referral to definitive treatment the outcome remains poor.

The second scenario involves injured players, where an ASCI is not immediately apparent. In this case the injury may appear to be serious and the player is removed from the game, but the injury is not treated as a neck injury. Again, in most cases the outcome is already determined as the injury is less severe and stable, with the player determining safe movement within limits of pain.

The third scenario involves players who have severe injuries that are not immediately apparent or recognised. This may be due to subtle clinical presentation or inadequately trained medical support who do not recognise the severity of the injury. In this group, which are represented by the sub-optimal group in Table 12, there appears clinically relevant evidence that there is an increased likelihood of a poorer outcome (62 % permanent outcome) when sub-optimal treatment is used, and full immobilisation and a rapid referral to a tertiary institute is not applied. Although, there are no statistically significant results between on-field management and outcome, it does appear that there are several important reasons to review the BokSmart programme to address the following discussion points.

BokSmart is primarily a programme that aims to educate coaches and referees around making the game safer to lower the incidence of catastrophic injuries (12). In addition, BokSmart provides a rugby medic programme to educate people involved in rugby across all areas. Between 2008 and 2016, 2773 facilities, including 1593 schools and 1099 rugby clubs, have offered courses training interested members as rugby medics. A total of 35,421 rugby medics were trained with most trained members being Black (60 %) or of Mixed ancestry (27 %). (Dr Viljoen, *personal communication*). Despite this, these ethnicities remain at risk with a 2.4 times higher proportion of permanent ASCIs. This suggests there has not been real change in outcome since the earlier study by Hermanus et al in 2007 (39). As ethnicity is so closely linked to socio-economic status and low socio economic status is linked to health outcomes in South Africa (36), it suggests that barriers to training facilities, medical personnel, equipment and transport to an appropriate tertiary medical facility remain, but are part of the broader political and economic realities of South Africa. Until these national issues are addressed the outcome of ASCI and other catastrophic injuries may not improve, and BokSmart may not be able to drive meaningful changes in catastrophic injuries alone. If we assume that ethnicity in South Africa is used as a proxy for SES (31, 36), the results of this study appear to have shown that in the face of improved access to field side emergency equipment and expertise - as seen by the increase in numbers of players receiving optimal treatment and management, - the primary reason for the increased risk in black players remains factors associated with SES. These factors are not specific to rugby but are relevant as rugby is a collision sport, and physical parameters are important in injury prevention. In South Africa, SES affects optimal nutrition and in turn optimal development and growth, education and organised physical activity at schools. ,Coaching, sport specific training and strength and conditioning are also associated with SES (38). Conditioning is especially important as there is evidence that poor scoring on preseason functional movement testing in rugby players can predict severe contact injury occurrence (78). These factors appear to be key in preparing the athlete to be optimally resilient against all injuries, including catastrophic injuries. In addition, BokSmart needs to continue to accurately record these injuries, and must continue to educate players and officials around player welfare.

The introduction of BokSmart to South Africa has been associated with a significant reduction in the incidence of catastrophic injuries (7). The BokSmart Spineline, a toll-free number operated by BokSmart's emergency service provider (ER24) is the first point of contact in the case of a catastrophic injury. In the case of a suspected serious and/or catastrophic injury to the head, neck, spine, brain or fatality of an injured rugby player, the Serious Injury Case Manager (SICM) will provide the link between the relevant club, school or team and SARU. (BokSmart Serious Injury Protocol).

However, this study shows that the knowledge around Spineline and its use can be improved, and although well branded and marketed through BokSmart, the lack of ownership of serious injury management by referee's and coaches (only two coaches and one referee were involved in management of an ASCI) means that the programme is not being fully implemented. This view is supported by a recently published study on BokSmart, where seven focus groups consisting of referees and coaches of various SES groups were held. The consensus among these stakeholders was that BokSmart did have the power to reduce catastrophic injuries, but the perceived barriers to this varied across different SES groups (31). This supports the conclusion that SES is also important in determining which barriers to implementation need to be removed.

It is suggested that Spineline is re-launched and advertised more broadly to the public. A proposal is that Spineline advertising hoardings are positioned at each ground, in clear view of the public above any first aid/medical station. This is cost effective, and visible to all stakeholders of the game. This should provide a recognisable, and visible reminder to all, that in the case of a catastrophic injury, Spineline must always be contacted. By increasing the usage of Spineline, there will be quicker notification and management of the injury by the serious case manager, and this will ensure correct management, minimise delays and ensure collection of critical data that gets lost or forgotten when there is a delay.

It is also recommended that the measurement of permanent neurological outcome at one month post injury is reviewed. There is significant evidence that further neurological improvement can take place up to one year. It is recommended that final classification of complete vs incomplete ASCI should be done at one year post injury, and this data used for final outcome.

There were a few limitations with this study. For most questions, there was substantial data missing. In part, this could be due to the nature of this research. However, where possible, the BokSmart serious injury questionnaire should be simplified and written in an algorithmic way. Algorithms will simplify the questionnaire by providing only two alternative answers to a question. This will also take cognisance of the fact that English is only the fourth most spoken language in South Africa (77). Qualitative research would be a better alternative to open ended questions and will reduce ambiguity and missing data. This will improve the statistical power of future studies.

Medical personnel in rugby, outside of the elite level, are not obliged or trained to maintain competence regarding emergency management of players, and if they are medically trained they are often not exposed to BokSmart and specifically Spineline which is rugby specific (15). Medical personnel should be required to be recertified biannually through BokSmart. This would align them with the requirements of coaches and referees (31). This will ensure medical personnel who are managing all on field injuries, including catastrophic injuries are competent and current in the management of rugby related catastrophic injuries. This is already required by World Rugby at elite level where all medical personnel are required to have Immediate Care in Rugby (ICIR) level two certification. If this is not practical, then BokSmart needs to identify the Rugby Medic programme as the means of providing the education and audited authority to manage the process independently of player management when a more senior medically trained person is present. The Rugby Medic programme, and roll out of emergency equipment needs to be prioritised and a similar recertification programme needs to be provided to ensure rugby medics are competent and up to date.

Within the BokSmart Safety in the Playing Environment document, there are footnotes noting the minimum requirements to host a game. These should be modified when it is not feasible to hold the game due to certain medical equipment and personnel not being in place due to financial constraints (15). This suggests that in areas outside the greater metropoles, where BokSmart has less penetration, there is a greater need for a rugby Medic programme, than the current coach and referee focussed education and certification provides.

There was no association between the immediate post injury management and outcome of an ASCI. Although, initially unexpected, the need to prevent these injuries needs to continue to be highlighted through the BokSmart programme. Also, a BokSmart Medic programme would be beneficial to ensure the symptoms of a not-so-obvious ASCI are recognised and receive optimal treatment. In the event of an ASCI, a revised, simpler and more accessible BokSmart serious injury follow up questionnaire will ensure the continued record of useful information to keep driving this intervention.

In conclusion, at the onset this study attempted to answer several questions. These questions are repeated below, with brief answers.

1. Has the BokSmart serious injury protocol been followed when catastrophic injuries have occurred?

   There has been an increase in the number of players who have had optimal treatment following an injury, however, there are still too many cases where Spineline was not contacted. In these cases, the BokSmart serious injury protocol was often not followed.

2. Are there demographic factors which affect outcome in catastrophic injuries?

   Ethnicity as a proxy for socioeconomic status, did have an effect on outcome in Acute Spinal Cord Injuries in this study. However, it was felt that socioeconomic disparity remains the driving force behind differences found between ethnic groups.

3. Which management and/or safety factors are associated with a better outcome?

This study did not identify any emergency management factors or safety factors that were associated with a better outcome in ASCI's.

4. Is the wearing of protective equipment associated with better outcome?

This study did not show any association between the wearing of protective equipment and a better outcome in ASCI in the tackle situation.

5. Is on-field management of catastrophic injuries associated with better outcome?

Management initiated on the field of play was not associated with a better outcome in ASCI. However, in players where initial presentation as an ASCI was not obvious there appeared to be a clinical significance where treatment was optimised.

6. Is full immobilisation associated with better outcomes

Optimal immobilisation, was not associated with a better outcome in ASCI. However, it is still recommended from a clinical perspective that immobilisation should occur until imaging and specialist care is available.

7. Is a delay in transport to hospital associated with worse outcome?

There was no association between a delay in transport to definitive care and outcome in ASCI's.

8. Is a delay in definitive treatment associated with worse outcome?

A delay in definitive treatment was not associated with a worse outcome in ASCI's in this study.

9. Is management and outcome affected by expertise at the side of the field?

There was no association between side of field expertise and outcome in this study.

10. Does BokSmart target the correct personnel?

It appears that Spineline education is not targeting the correct personnel, and further research is required to target this education more appropriately.

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Appendices

Appendix A – Serious injury follow up questionnaire

BokSmart

WINNERS PLAY SMART

BOKSMART 2011

SERIOUS INJURY FOLLOW-UP QUESTIONNAIRE

A serious and/or catastrophic injury is defined as any head, neck, spine, or brain injury that is life-threatening or potentially permanently debilitating and results in the emergency admission of a rugby player to a hospital or medical care centre.

Providing coaches, referees, players, and administrators with the knowledge, skills, and leadership abilities to ensure that safety and best practice principles are incorporated into all aspects of contact rugby.

SA RUGBY.

ABSA

CHRIS BURGER PLAYERS FUND PETRO JACKSON

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A joint initiative by SARU and the Chris Burger/Petro Jackson Fund

WHAT TO DO!

- In the event of a serious and/or catastrophic injury meeting the above mentioned criteria, the following form should be completed by the injured player and/or coach in conjunction with the Serious Injury Case Manager(Ms. Gail Ross – Cell: 0728903538, email: gailross@mweb.co.za, fax: 021-6595653)
- If for some reason this is not possible, then the questionnaire should be completed by the Serious Injury Case Manager in consultation with the coach, other players, and family who might have seen the incident
- Although it might be sensitive and emotional to recall the incident, it would benefit rugby and future rugby players if the follow-up questionnaire is completed while the incident is still fresh in everyone's minds
- This form should then be kept on record pending any inquest or investigation
- Copies should be sent to the SARU Medical Manager and BokSmart General Manager

RESEARCH

All serious injury data collected will be recorded and stored on a SARU database. Personal details will be provided to the Chris Burger/Petro Jackson Players Fund, who may provide financial assistance and support to catastrophically injured rugby players. This information will be stored at SARU's offices for official records of these injuries. The injury data may be used for research and publication purposes to help improve the safety standards of the game of rugby in South Africa, and to potentially prevent other injuries of this nature from occurring in the future. However, in this instance, all personal information will be regarded as confidential in any ensuing research analyses and reports on the catastrophically injured players.

☐ By ticking this box, the player agrees to the above

INTERNATIONAL RUGBY BOARD (IRB)

All data collected will be forwarded anonymously to the IRB and stored in a secure IRB database of catastrophic injuries. These data may be analysed by the IRB for audit, player welfare, research purposes in relation to the prevention, and management of Rugby-related catastrophic injuries.

☐ By ticking this box, the player agrees to the above

PLAYER'S CONSENT

It is hereby confirmed that the player or player's family, whichever may be applicable, has given permission to use and submit the information requested by this form and that they agreed that the information can be forwarded to the IRB, and be used by both SARU and the IRB for the purposes of monitoring and investigating the causes of catastrophic injuries sustained in Rugby Union.

☐ By ticking this box, the player agrees to the above

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SECTION A: PERSONAL DETAILS (PRINT CLEARLY)

Surname: ______________________ Age of Player: ______________________

Forenames: ______________________ Known as (nickname): _______________

Date that form was completed:

D D / M M / Y Y Y Y

Email address: ____

ID Number:

Passport Number:

Passport type (country of issue): ____________________________

Marital status: ____________________________

Playing position: ____________________________

SARU Registration number: ____________________________

Residential address:

____

____

____

____

Tel./Cell. Number: ____________________________

Next of Kin: ____________________________

Contact number (next of kin): ____________________________

Name of Rugby Club/School: ______________________________

Provincial Union (e.g. Bulls): ______________________________

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1. Date of Birth [D][D] / [M][M] / [Y][Y][Y][Y]

2. Gender: ☐ Male ☐ Female

3. Player's Weight in Kilogram (kg)

    a. At the time of Injury: ___________kg

    b. What is the player's current weight? ___________kg

4. Player's Height in Cm at the time of injury (cm): __________cm

5. Country of birth: ____

6. Ethnicity:

- ☐ Arabic
- ☐ Asian
- ☐ Black African
- ☐ Black Caribbean
- ☐ Pacific Islander
- ☐ White
- ☐ Coloured/Mixed Ancestry
- ☐ Indian
- ☐ Other

7. What age did the player start playing rugby? _______________________________

8. Number of years that the player has been playing rugby: ______________________

9. How many seasons of rugby has the player played prior to this season:_______________

10. Grade of play

    a. Player's current grade of play (please select highest level of play)

- ☐ School
- ☐ School Provincial
- ☐ School International
- ☐ Club
- ☐ Non-professional Provincial
- ☐ Professional Provincial
- ☐ International

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b. Player's current playing age-group

- ☐ Junior (<U13)
- ☐ U13
- ☐ U14
- ☐ U15
- ☐ U16
- ☐ U17
- ☐ U18
- ☐ U19
- ☐ U21
- ☐ U23
- ☐ Senior

c. Is the player registered at their Province?

☐ Yes ☐ No

d. Is the player registered at SARU?

☐ Yes ☐ No

11. Player's *Usual* playing position:

- ☐ 1 – Loose-head prop
- ☐ 2 – Hooker
- ☐ 3 – Tight-head prop
- ☐ 4 – Lock
- ☐ 5 – Lock
- ☐ 6 – Open-side flank
- ☐ 7 – Blind-side flank
- ☐ 8 – Eighth man
- ☐ 9 – Scrum/Inside half
- ☐ 10 – Fly/Outside half
- ☐ 11 – Left Wing
- ☐ 12 – Inside centre
- ☐ 13 – Outside centre
- ☐ 14 – Right Wing
- ☐ 15 – Full back

12. Number of years the player has been playing in this position: ___________

13. Provide any specific, relevant information about the player's background:

____
____
____
____
____
____

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SECTION B: INJURY CIRCUMSTANCES (PRINT CLEARLY)

14. How well did the player recall the events of the day?

- ☐ No recollection
- ☐ Vaguely remembered
- ☐ Somewhat
- ☐ Well
- ☐ Extremely well

15.

a. Date of Injury

D D / M M / Y Y Y Y

b. Time that the injury occurred:

H H : M M am / pm

16. Did the injury occur during:

- ☐ Match
  - ☐ 15-a-side match
  - ☐ 7-a-side match

- ☐ Training activity
  - ☐ Rugby skills training, Full contact
  - ☐ Rugby skills training, Semi-contact
  - ☐ Rugby skills training, Non-contact

- ☐ Was match/training under:
  - ☐ Natural light
  - ☐ Artificial light

- ☐ Other (please specify): ____

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17.

a. At what stage of the season did the injury occur?

- ☐ Off-season
- ☐ Pre-season
- ☐ In-season
    - ☐ First month of the season
    - ☐ Mid-season
    - ☐ Last month of the season

b. What type of match was it?

Level of the game

- ☐ School
- ☐ School Provincial
- ☐ School International
- ☐ Club
- ☐ Non-professional Provincial
- ☐ Professional Provincial
- ☐ International

Type of game

- ☐ Tournament/Competition
- ☐ Friendly match
- ☐ League match
- ☐ Practice match
- ☐ Social match
- ☐ Hostel league match
- ☐ Farm league match
- ☐ Informal league match

c. Grade of opposition

- ☐ School
- ☐ School Provincial
- ☐ School International
- ☐ Club
- ☐ Non-professional Provincial
- ☐ Professional Provincial
- ☐ International

d. In which period of the game did the injury occur?

- ☐ Warm-up
- ☐ 1st Quarter
- ☐ 2nd Quarter
- ☐ 3rd Quarter
- ☐ 4th Quarter
- ☐ Cool-down

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e. Was the incident leading to the injury as a result of foul or dangerous play as defined in Law 10.4 “Dangerous Play and Misconduct”?

☐ Yes ☐ No

If *Yes*, then answer *17f* and if answered *No*, then complete *17g*

f. Classifications of dangerous play

- ☐ Punching or striking
- ☐ Stamping or trampling
- ☐ Kicking
- ☐ Tripping
- ☐ Early or late tackle
- ☐ Tackle above the line of the shoulders
- ☐ Stiff-arm tackle
- ☐ Playing a player without the ball
- ☐ Tackling an opponent whose feet are off the ground
- ☐ Dangerous charging
- ☐ Scrum front row rushing opponents
- ☐ Scrum front row lifting opponents
- ☐ Collapsing a scrum, ruck or maul
- ☐ Tip/lifting/spear tackle
- ☐ Retaliation

g. Did the referee take any action?

☐ Yes ☐ No

Explain:____

____

____

h. Playing position *at the time of injury*

- ☐ 1 – Loose-head prop
- ☐ 2 – Hooker
- ☐ 3 – Tight-head prop
- ☐ 4 – Lock
- ☐ 5 – Lock
- ☐ 6 – Open-side flank
- ☐ 7 – Blind-side flank
- ☐ 8 – Eighth man
- ☐ 9 – Scrum/Inside half
- ☐ 10 – Fly/Outside half
- ☐ 11- Left Wing
- ☐ 12 – Inside centre
- ☐ 13 – Outside centre
- ☐ 14 – Right Wing
- ☐ 15 – Full back

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i. Was the player playing in his/her usual playing position?

☐ Yes ☐ No

If the player answered No, and was not playing in his/her usual position, then give the reason why?

____
____
____
____
____

18. Who was officiating or leading the match / training session?

☐ Referee
☐ Coach
☐ No-one
☐ Player
☐ Spectator
☐ Teacher
☐ Other (Please specify)_____________

19. Was a Union-appointed referee in control of the game?

☐ Yes ☐ No

20.

a. Had the referee attended a SARU or IRB Level referee-training course?

☐ Yes ☐ No

b. If Yes then give details of referee's training:

____
____

c. Date of the most recent course attended

D D / M M / Y Y Y Y

d. Had the referee attended a BokSmart Rugby Safety course?

☐ Yes ☐ No

e. If Yes then provide the referee's BS-number: _________

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f. Had the coach attended a SARU or IRB Level coaching course?

☐ Yes ☐ No

g. If Yes then give details of the coach's training:

____

____

h. Date of the most recent course attended

D D / M M / Y Y Y Y

i. Had the coach attended a BokSmart Rugby Safety course?

☐ Yes ☐ No

j. If Yes then provide the coach's BS-number: __________

21. Briefly describe the events that led up to the injury (if possible in the player's own words):

____

____

____

____

____

SECTION C: INJURY EVENT (PRINT CLEARLY)

22.

a. Did the player warm-up properly before the match or training session?

☐ Yes ☐ No

b. Did the player stretch before the match or training session?

☐ Yes ☐ No

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23. Indicate the <u>event</u> causing the catastrophic injury (thereafter, please describe and answer the *relevant and corresponding <u>event</u>* section):

- ☐ Collision
- ☐ Tackle
- ☐ Scrum
- ☐ Ruck
- ☐ Maul
- ☐ Lineout
- ☐ Kicking
- ☐ Running
- ☐ Other:____________________
- ☐ Unclear
- ☐ Not applicable

24. ☐ *<u>Tackle</u>*

a. What was the injured player's role in the tackle?

- ☐ Ball carrier
  - ☐ Tackled from behind
  - ☐ Tackled from the side
  - ☐ Tackled from the front

- ☐ Support player to ball carrier

- ☐ Tackler
  - ☐ Tackling from behind
  - ☐ Tackling from the side
  - ☐ Tackling from the front

- ☐ Support player to tackler

b. What type of contact was involved?

- ☐ Arm
- ☐ Collision (no-arms, deliberate)
- ☐ Jersey
- ☐ Lift (example spear)
- ☐ Shoulder
- ☐ Smother
- ☐ Tap

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c. Indicate the following specifics as best you can with regards to the tackle situation;

ROLE	TACKLE HEIGHT	TACKLE DIRECTION	TACKLER'S VELOCITY	BALL CARRIER'S STANCE	BALL CARRIER'S VELOCITY
Ball carrier	High	Front-on	Fast	Upright	Fast
Tackler	Middle	Side-on	Slow	Low position	Slow
Support player	Low	From behind	Standing still	Falling/diving	Standing still

d. Tick off all the additional specifics as best you can with regards to the tackle situation;

Number of Tacklers	Tackle Type
1	Arms wrapped around the player
2	Shoulder charge (no arms used in the tackle)
3 or more	Spear tackle/pile drive (head below shoulders)
	Head is first point of contact with the ground
	Pulled /scragged by the collar

e. Please provide any further information relevant to the tackle e.g. head was first point of contact with the ground, upper body was first contact with the post, etc.

____

____

____

____

25.

☐ *Scrum*

a. Was the scrum part of a training session or match

☐ Training session
☐ Match

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b. If during Training, then was this against a scrum machine or live opposition?

☐ Scrum machine
  ☐ How many players were going in against the machine?____

☐ Live opposition
  Indicate below how many players were contesting the scrum for both packs?

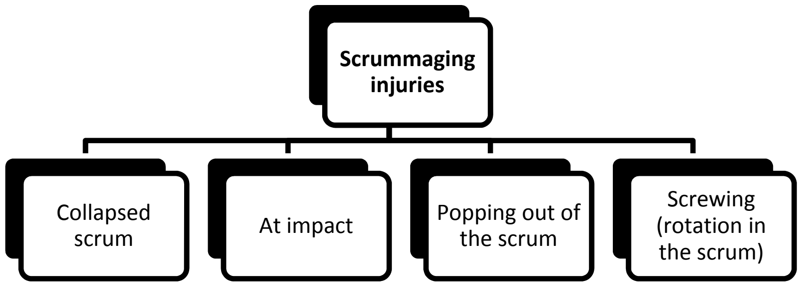
Injured player's team	Opposition team
☐ 3	☐ 3
☐ 5	☐ 5
☐ 6	☐ 6
☐ 7	☐ 7
☐ 8	☐ 8

c. Which team had the put-in in the scrum?

☐ Player's own team
☐ Opposition team

d. Did the injury involve any of the following:

☐ Collapsed scrum
☐ Impact on engagement
☐ Player popping out of the scrum
☐ Scrum wheeling/rotating



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e. Please provide any further information relevant to the scrum e.g. which player popped first, which team collapsed first, number of scrum resets, make and age of scrum machine etc.

____
____
____
____

26.

☐ *Ruck* or ☐ *Maul*

a. What was the injured player's role in the ruck/maul?

☐ Ball carrier
☐ Support player to ball carrier
☐ Tackler
☐ Support player to tackler

b. Body position at the time of injury

☐ On feet
☐ Off feet
☐ Bridging
☐ Supported

c. During the ruck/maul did the injury occur during any of the following?

☐ Cleaning out
☐ Cleaned out
☐ Collapsed maul
☐ Squeeze ball (ball pinned between legs)
☐ Other (please specify)____

d. Please provide any further information relevant to the ruck/maul

____
____
____
____

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27.

☐ *Lineout*

a. Identify how the injury occurred:

☐ 'Lifted player' fell during landing (no other player involved)
☐ 'Lifted player' fell during landing (other player(s) involved)
☐ 'Lifting player' injured (no other player involved)
☐ 'Lifting player' injured (other player(s) involved)
☐ Other (please specify below)

b. Please provide any further information relevant to the lineout e.g. which body part first made contact with the ground, etc.

____
____
____
____

28. Other categories

☐ Non-contact training
☐ Collision (if accidental, then describe below)
☐ Kicking
☐ Running

a. Please provide relevant information to the activity being undertaken at the time of injury e.g. weight training, passing drills, running drills, phase play simulations etc.

____
____
____
____

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SECTION D: IMMEDIATE POST-INJURY CARE (PRINT CLEARLY)

29.

a. Who of the following *medical or allied health professionals* were the first to provide on-field treatment or support to the injured player during the match or training session?

☐ Medical Doctor
☐ Physiotherapist
☐ Biokineticist
☐ Emergency Service Medic (paramedic)
☐ First Aider
☐ Nurse
☐ None

b. When was the injured player FIRST attended to by the medical or allied health professional?

☐ On the pitch
☐ Off the pitch

30. Was the player FIRST attended to by someone OTHER than a medical or allied health professional?

☐ Yes ☐ No

a. If answered Yes, then by whom?

☐ BokSmart Rugby Medic
☐ Coach
☐ Referee
☐ Spectator
☐ Team official
☐ Other (Please specify)___________________________

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b. What actions were taken by this person?

☐ Player moved on the pitch
☐ Player removed from the pitch
☐ None e.g. waited for arrival of the paramedics/doctor
☐ Other (Please specify)___________________________

31. Who managed/assisted with the <u>removal</u> of the player from the pitch?

☐ Medical Doctor
☐ Physiotherapist
☐ Biokineticist
☐ Emergency Service Medic (paramedic)
☐ First Aider
☐ Nurse
☐ BokSmart Rugby Medic
☐ Coach
☐ Referee
☐ Spectator
☐ Team official
☐ Player walked off unassisted
☐ Other player(s)
☐ Other (Please specify)__________________________

32. What equipment was used in the removal of the injured player from the pitch?

a. Did they place a brace/collar over the neck? ☐ Yes ☐ No
b. Was the injured player placed on a stretcher? ☐ Yes ☐ No
c. Was the injured player placed on a spinal board? ☐ Yes ☐ No
d. Was the injured player stabilised using a spider harness? ☐ Yes ☐ No
e. Were head-blocks used to immobilise/stabilise the injured player's head and neck? ☐ Yes ☐ No
f. Was Oxygen used? ☐ Yes ☐ No
g. Other (Please specify)_____________________________

33. Did the player *<u>leave</u>* the field at any time during the match *<u>before</u>* the injury and *<u>return</u>* to the field of play?

☐ Yes ☐ No

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34. Was the BokSmart Spineline number (***0800 678 678***) contacted at any given stage during the management of the injured player?

☐ Yes ☐ No

If answered No, then why not?

____
____
____

35. Was the player taken *immediately* to hospital?

☐ Yes ☐ No

a. How long did the player have to wait before being taken to hospital?

☐ < 1 hour
☐ 1-2 hours
☐ 2-3 hours
☐ 3-4 hours
☐ > 4 hours

b. If more than 4 hours passed before being taken to hospital, then please specify the reasons why?

____
____
____

36. How was the injured player taken to hospital?

☐ Ambulance
☐ Car
☐ Helicopter
☐ Other (Please specify)_______________________________

37. What hospital/medical facilities was the player taken to?

____
____
____

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38. Was the injured player wearing any of the following at the time?

☐ Mouthguard
☐ Shoulder pads
☐ Headgear

SECTION E: EXPERIENCE AND TRAINING (PRINT CLEARLY)

39. The number of games played by the injured player ***this season*** prior to injury? _______________

40. Within the last 12 months did the injured player receive training from a qualified coach/trainer on how to *safely* and *correctly* perform the following activities?

    a. Tackling techniques ☐Yes ☐No
    b. Ball carrying techniques ☐Yes ☐No
    c. Safe techniques in contact ☐Yes ☐No
    d. Scrum techniques ☐Yes ☐No ☐Not relevant
    e. Scrum engagement ☐Yes ☐No ☐Not relevant
    f. Falling correctly in a collapsed scrum ☐Yes ☐No ☐Not relevant
    g. Ruck techniques ☐Yes ☐No
    h. Entering the ruck ☐Yes ☐No
    i. Maul techniques ☐Yes ☐No
    j. Entering a maul ☐Yes ☐No
    k. Lineout techniques ☐Yes ☐No ☐Not relevant
    l. Supporting in a lineout ☐Yes ☐No ☐Not relevant
    m. Supporting a jumper at kick-off ☐Yes ☐No ☐Not relevant

41. Did the player have a *regular coach* other than the head coach of the team in charge of his/her rugby development?

    ☐ Yes ☐ No

    If Yes, then answer 41 (a- e)

    a. Had the coach attended a SARU or IRB Level coaching course?

    ☐ Yes ☐ No

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b. If Yes then give details of the coach's training:

____

____

c. Date of the most recent course attended

D D / M M / Y Y Y Y

d. Had the coach attended a BokSmart Rugby Safety course?

☐ Yes ☐ No

e. If Yes then provide the coach's BS-number: _________

42.

a. Did the player receive specific <u>coaching</u> for his/her position by a qualified coach?

☐ Yes ☐ No

b. Did the player receive specific <u>conditioning</u> for his/her position by a qualified trainer?

☐ Yes ☐ No

43. How long <u>before</u> the season did the player take part in <u>pre-season</u> strength and fitness conditioning?

☐ Never
☐ 1-2 weeks
☐ 3-4 weeks
☐ 1-2 months
☐ 2-3 months
☐ ≥ 3 months

44. How many training sessions did the player undertake each week during the <u>pre-season</u> training period? (Please give number of sessions or 0 if none was undertaken)

a. Individual training sessions per week _______
b. Team training sessions per week _______

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45. On average, how many formal structured rugby training sessions did the player perform per week (at the time of injury)?

- ☐ Never
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ More than 3

46. Other than the official team training sessions, what individual training did the player perform? Specify how often, the type of activity, average duration of each session, etc.

Activity	**Intensity**				**How many times per week**	**Average duration (min)**
	Easy	*Moderate*	*Tough*	*Very hard*		
_____________	E	M	T	VH	_________________________	_________min
_____________	E	M	T	VH	_________________________	_________min
_____________	E	M	T	VH	_________________________	_________min
_____________	E	M	T	VH	_________________________	_________min
_____________	E	M	T	VH	_________________________	_________min

47. Did the player participate in any strength/resistance/weight training at least twice per week during the season?

☐ Yes ☐ No

If YES, then for how many years has the player been performing structured strength/resistance/weight training and specify to what degree?

____

____

____

48. Did the player participate in any <u>neck</u> strengthening exercises?

☐ Yes ☐ No

If YES, specify:

- ☐ Rarely, no more than 1 session per season
- ☐ Occasionally, less than 1 session per month
- ☐ Often, at least 1 session per month
- ☐ Regularly, at least 1 session per week

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For more detail on *neck strengthening*, please complete the table below:

Activity	**Intensity**				**How many times per week**	**Average duration (min)**
	Easy	*Moderate*	*Tough*	*Very hard*		
____________	E	M	T	VH	_______________________	________min
____________	E	M	T	VH	_______________________	________min
____________	E	M	T	VH	_______________________	________min
____________	E	M	T	VH	_______________________	________min
____________	E	M	T	VH	_______________________	________min

49. Compared to the injured player's *normal* training regime, in the week preceding the injury, what was the training level?

    a. Training Volume

    ☐ Lower
    ☐ The same
    ☐ Higher

    b. Training Intensity

    ☐ Lower
    ☐ The same
    ☐ Higher

50. If injured in the *scrum*, then please answer the following:

    a. How many scrum engagements did the injured player typically practice per session? ______________________

    b. Compared to the injured player's *normal* training regime, in the week preceding the injury, what was the SCRUM SPECIFIC training level:

        i. Training Volume

        ☐ Lower
        ☐ The same
        ☐ Higher

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ii. Training Intensity

- ▢ Lower
- ▢ The same
- ▢ Higher

51. Did the player follow any special diet/eating plan before or during the season?

▢ Yes ▢ No

52. Did the player use any specific supplements before or during the season?

▢ Yes ▢ No

a. If YES, elaborate

____
____
____

SECTION F: PLAYING CONDITIONS (PRINT CLEARLY)

53. What was the weather like on the day of injury? Please tick all of the appropriate answers:

▢ Hot	▢ Cold
▢ Dry	▢ Heavy Rain
▢ Light Rain	▢ Windy
▢ Overcast	▢ Other (Please specify):______________

a. Were the weather conditions on the day of the player's injury *typical* for the location and time of year?

▢ Yes ▢ No

b. If NO, what are the typical weather conditions for the location and time of year at which the injury occurred?

____
____
____

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c. What was the temperature at the time of injury? (You can get this information from the local weather service)____________________________

54. On what type of surface did the injury occur?

- ☐ Wood e.g. gym floor
- ☐ Tarmac or similar
- ☐ Concrete
- ☐ Natural grass
- ☐ Artificial turf – rubber infill
- ☐ Artificial turf – sand infill
- ☐ Dirt or sand
- ☐ Gravel
- ☐ Other (Please specify):_____________

55. How hard was the field or surface?

- ☐ Soft
- ☐ Firm
- ☐ Very hard

56. How was the surface of the field?

- ☐ Slippery
- ☐ Medium grip
- ☐ Good, solid footing (hard grip)

57. What was the condition of the playing surface?

a. ☐ Even
   - ☐ Flat and rough
   - ☐ Flat and smooth

b. ☐ Uneven
   - ☐ Sloping and rough
   - ☐ Sloping and smooth

58. Does the player feel that the field condition contributed towards the injury?

☐ Yes ☐ No

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59. If answered YES, please specify

____
____
____

60. What type of footwear was the player using at the time of injury?

- ☐ None
- ☐ Trainers/tekkies
- ☐ Studded boots
- ☐ Other (Please specify):____

61. If wearing studded boots, please tick all applicable answers below:

- ☐ Brand new
- ☐ Worn in
- ☐ Old/damaged
- ☐ Short studs
- ☐ Long studs
- ☐ Multi studs
- ☐ Six studs
- ☐ Other (Please specify):____

62. In the player's opinion, what was the main cause of his/her injury?

____
____
____

63. Does the player have any recommendations to prevent others from sustaining a similar injury?

____
____
____

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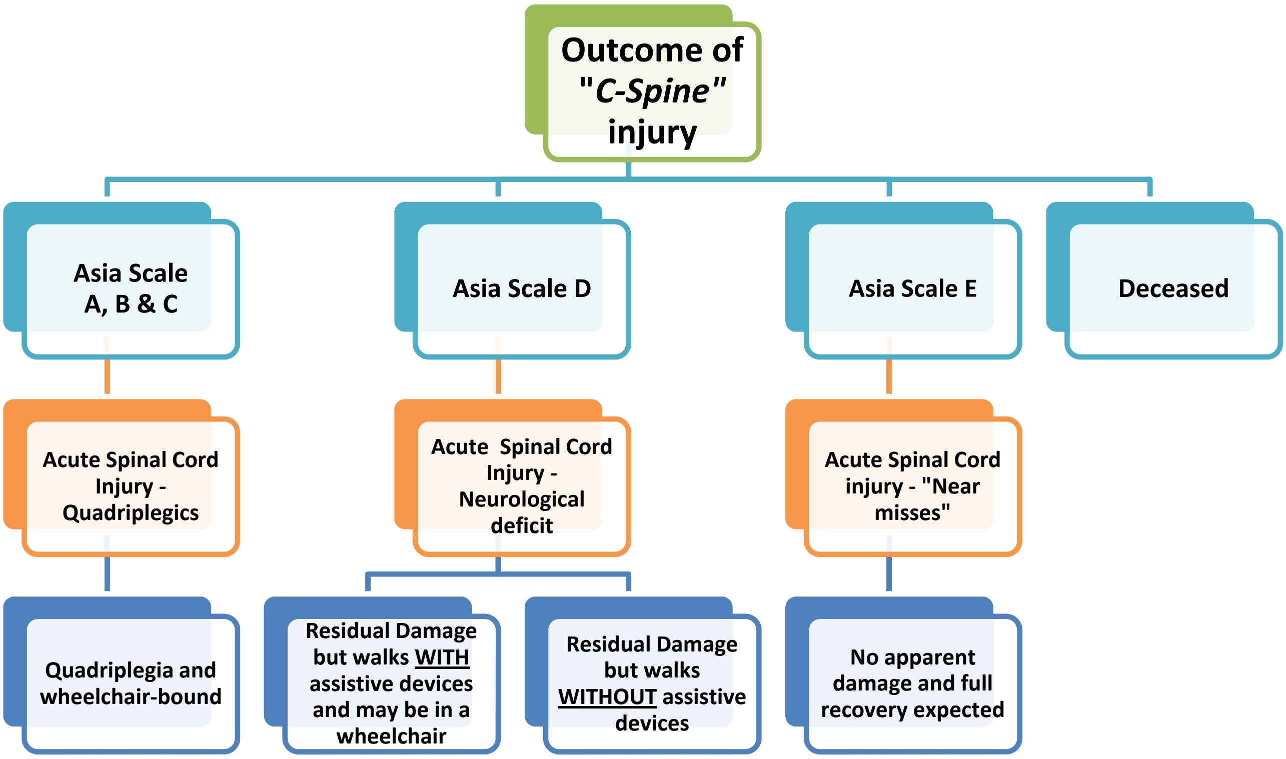
SECTION G: OUTCOME OF INJURY (PRINT CLEARLY)

Outcome of Injury Classification Matrix for *Cervical Spinal Cord* Injuries (C1-C7):



64. What was the initial hospital-based *diagnosis*?

- ☐ Deceased
  - ☐ A fatal spinal cord injury
  - ☐ A fatal head injury
  - ☐ Cardiac event
  - ☐ Other e.g. stroke:_____________________________
- ☐ Non-fatal Spinal Cord Injury
  - ☐ Quadriplegia and Wheelchair bound
  - ☐ Potential catastrophic injury with recovery (residual damage but walks with assistive devices and may be in a wheelchair)
  - ☐ Potential catastrophic injury with recovery (residual damage but walks without assistive devices)
  - ☐ No apparent residual damage and full recovery expected

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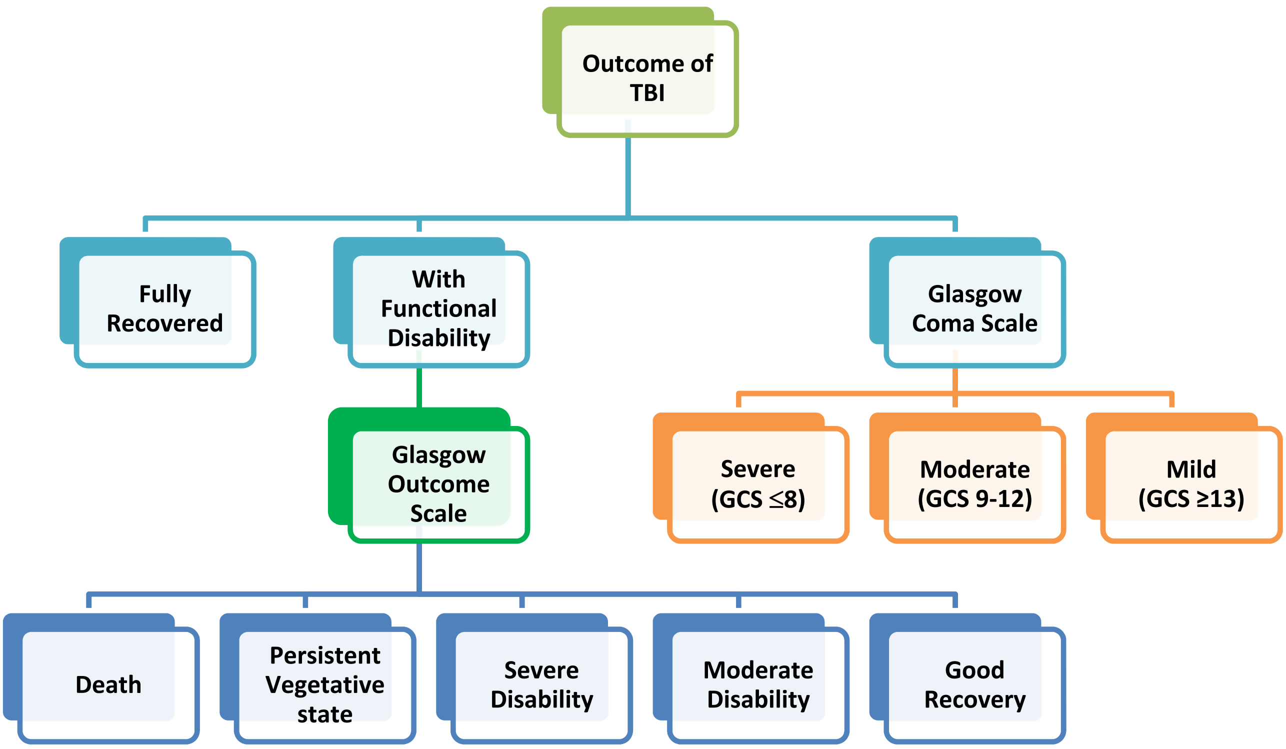
- ☐ Head injuries (see Question 66)
  - ☐ Fully recovered
  - ☐ With disability

65. Asia Impairment Scale for *Cervical Spinal Cord* injured players at time of diagnosis

- ☐ A – *Complete*: no motor or sensory function is preserved in the sacral segments S4-S5
- ☐ B – *Incomplete*: sensory but not motor function is preserved below the neurological level, and includes the sacral segments S4-S5
- ☐ C – *Incomplete*: motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3
- ☐ D – *Incomplete*: motor function is preserved below the neurological level and at least half of key muscles below the neurological level have a muscle grade of 3 or more
- ☐ E – *Normal*: motor and sensory function are normal

Outcome of Injury Classification Matrix for *Head or TBI* Injuries



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66. *Glasgow Coma Scale* (GCS) for Head or Brain (TBI) injured players at time of *diagnosis*:

- ☐ *Mild (GCS ≥ 13)* – loss of consciousness and/or confusion and disorientation was shorter than 30 minutes
- ☐ *Moderate (GCS 9-12)* – loss of consciousness >30 minutes; physical or cognitive impairments that may or may not resolve; benefit from rehabilitation
- ☐ *Severe (GCS ≤ 8)* – Coma; unconscious state; no meaningful response; no voluntary activities

67. *Glasgow Outcome Scale* (GOS) for Head or Brain (TBI) injured players at *discharge*:

- ☐ *Death*
- ☐ *Persistent Vegetative state* – A vegetative state that lasts for longer than 1 month. A vegetative state consists of sleep-wake cycles, arousal but no interaction with the environment and no localised response to pain
- ☐ *Severe Disability (conscious but disabled)* – patient depends on others for daily support due to mental or physical disability or both
- ☐ *Moderate disability (disabled but independent)* – patient is independent as far as daily life is concerned. The disability found includes varying degrees of dysphasia, hemiparesis, ataxia, as well as intellectual and memory deficits and personality changes
- ☐ *Good recovery* – Resumption of normal activities even though there may be minor neurological or psychological deficits

SECTION H: PLAYER'S MEDICAL HISTORY (PRINT CLEARLY)

68.

a. Did the player suffer from any medical conditions or illnesses that interrupted their training or match play in the week prior to the injury?

☐ Yes ☐ No

b. If YES, then describe the conditions/illnesses:

____

____

____

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69.

a. Does the player have any long-term medical conditions or illnesses that may be relevant to the injury e.g. epilepsy, diabetes?

☐ Yes ☐ No

b. If YES, then describe the conditions/illnesses:

____

____

____

70.

a. Does the player have a history of “stinger” (also known as burner, nerve pinch and brachial plexus injuries)?

☐ Yes ☐ No

b. If YES, then describe the history:

____

____

____

71.

a. Had the player ever sustained a previous *neck/spinal injury* before?

☐ Yes ☐ No

b. If YES, then please provide details of the nature and circumstances of the previous neck/spinal injury:

____

____

____

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c. Had the player ever sustained a previous *SIGNIFICANT neck/spinal* injury (that is requiring hospital admission or scans (MRI or CT scan), with prolonged symptoms for over 1 month, associated with arm symptoms or preventing play for more than 2 weeks):

☐ Yes ☐ No

d. If YES, then please provide details of the nature and circumstances of the previous SIGNIFICANT neck/spinal injury:

____
____
____

e. Had the player fully recovered from the previous SIGNIFICANT neck/spinal injury before starting the match/training session in which the current injury was sustained?

☐ Yes ☐ No

f. Did the player receive treatment for the previous neck/spinal injury?

☐ Yes ☐ No

g. Briefly describe the treatment received:

____
____
____

72.

a. Had the player ever sustained a previous *head/brain/concussion* injury before?

☐ Yes ☐ No

b. If YES, then please provide details of the nature and circumstances of the previous head/brain/concussion injury:

____
____
____

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c. Had the player ever sustained a previous *SIGNIFICANT head/brain/concussion* injury (with symptoms lasting more than 3 weeks or requiring hospital admission or scans (MRI or CT scan)):

☐ Yes ☐ No

d. If YES, then please provide details of the nature and circumstances of the previous SIGNIFICANT head/brain/concussion injury:

____

____

____

e. Had the player fully recovered from the previous SIGNIFICANT head/brain/concussion injury before starting the match/training session in which the current injury was sustained?

☐ Yes ☐ No

f. Did the player receive treatment for the previous SIGNIFICANT head/brain/concussion injury?

☐ Yes ☐ No

g. Briefly describe the treatment received:

____

____

____

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Appendix B – Miscellaneous tables

Overall, 65 % of the injured players (n=45) had head blocks applied as part of their emergency management for an ASCI (Table 1). Fifty-six % (n=25) who had head blocks applied as part of their emergency on field management had a permanent outcome, compared to 46 % (n=6) when the head blocks were not applied. There was no significant difference (p=0.388) between outcome in those players that had head blocks applied and those players that did not. (Table 1)

Table 1: Head blocks use in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	44% (n=20)	56% (n=25)
No	*0%*	54% (n=7)	46% (n=6)
Not applicable	*0%*	100% (n=2)	0%
Not provided	*(n=2)*	*(n=1)*	*(n=6)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

Fifty-five % (n=38) of suspected ASCI had a spider harness applied as part of their emergency management (Table 2). In those ASCI's where immobilization with a spider harness to a spinal board was used, there was a 53 % (n=20) incidence of permanent outcome, compared to a 50 % (n=9) permanent outcome where no spider harness immobilization was used. There was no significant difference in the outcomes between the two groups (p=0.540) (Table 2)

Table 2: Spider harness used for players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	47% (n=18)	53% (n=20)
No	*0%*	50% (n=9)	50% (n=9)
Not applicable	*0%*	100% (n=2)	0%
Not provided	*(n=2)*	(n=1)	(n=8)
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

A stretcher was used in ASCI management in only four cases (Table 3). There was a permanent outcome in 75 % (n=3) of cases where a stretcher was used for transport compared to 52 % (n=27) when a stretcher was not used. Seventy % of players used a spinal board.

Table 3: Use of stretcher in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	25% (n=1)	75% (n=3)
No	*0%*	48% (n=25)	52% (n=27)
Not applicable	*0%*	100% (n=2)	0%
Not provided	*(n=2)*	*(n=2)*	*(n=7)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

Table 4: Use of spinal board in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	45% (n=21)	55% (n=26)
No	*0%*	45% (n=5)	55% (n=6)
Not applicable	*0%*	100% (n=2)	0%
Not provided	*(n=2)*	*(n=2)*	*(n=5)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

Seventy % (n=48) of ASCI's had a rigid neck brace applied (Table 5). In those players who had a neck brace applied, significantly more (60 %, n=29) were associated with a permanent outcome than those who has no neck brace applied (27 %, n=3) (p=0.049).

Table 5: Use of neck brace in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
Yes	*0%*	40%(n=19)	60% (n=29)
No	*0%*	73% (n=8)	27% (n=3)
Not applicable	*0%*	100% (n=2)	0%
Not provided	*(n=2)*	*(n=1)*	*(n=5)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

In terms of the first responder to the injury, 46 % (n=25) of the players were treated by a medically trained person. There was no significant outcome difference (p=0.500) when the first on-field responder for an ASCI was medically trained or non-medically trained. Non-medical personnel include all responders who did not have formal medical training (including doctor, paramedic or physiotherapist), however they may have first aid or rugby medic training. Fifty-two % (n=13) of players managed on field by medical personnel had a non-permanent outcome. Forty-eight % (n=14) of players managed on field by a non-medical person had a non-permanent outcome (Table 6).

Table 6: On field first responder status - for players who sustained an acute spinal cord injury (ASCI)

	Not provided	**Non-Permanent**	**Permanent**
Medical personnel	*0%*	52% (n=13)	48% (n=12)
Non-Medical personnel	*0%*	48% (n=14)	52% (n=15)
None	*0%*	(n=1)	(n=6)
Not provided	*(n=2)*	(n=1)	(n=4)
Not applicable	*0%*	100% (n=1)	0%
Total	***3%*** *(n=2)*	**43%** (n=30)	**54%** (n=37)

The number of evacuations managed by trained non-medical persons (n=28) were similar to those managed by medical personnel (n=30). There were no differences in the outcomes of the injured players evacuated by medical or non-medical personnel (p=0.489). For example, 53 % (n=16) had a permanent outcome in medically managed evacuations compared to 57 % (n=16) having a permanent outcome in evacuations managed by non-medical personnel. (Table 7)

The outcome of players with an ASCI evacuated by unqualified non-medical people (no formal medical training and no BokSmart or First Aid accreditation) appeared worse with 100% of players managed by either a spectator or a coach having a permanent outcome. (Data not shown) The coach managed the removal of a player in four cases and a spectator in one case. As the total number of cases reported where the patient had been moved by non-medical personnel was small and the number of cases where data was not provided was high (n=7), it was not possible to interpret the findings with confidence.

Table 7: Medical vs. Non-medically managed evacuation for players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent
Medical	*0%*	47% (n=14)	53% (n=16)
Non-medical	*0%*	43% (n=12)	57% (n=16)
Not applicable	*0%*	100% (n=3) *	0%
Not provided	*(n=2)*	*(n=1)*	*(n=5)*
Total	***3%*** *(n=2)*	**43%** (n=30)	**54%** (n=37)

** fatalities*

Thirty-two players (89 %) had medical management which started on the pitch. There was no significant difference in outcome (p=0.699) when the player received their first medical attention on or off the pitch. Fifty % of players had permanent outcomes when treated on (n=16) or off (n=2) the pitch initially (Table 8). There were 32 injuries where data was not provided for this variable.

Table 8: Time of first medical attention in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent (%)
On the pitch	*0%*	50% (n=16)	50% (n=16)
Off the pitch	*0%*	50% (n=2)	50% (n=2)
Not provided	*(n=2)*	*(n=11)*	*(n=19)*
Not applicable	*0%*	(n=1) *	0%
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

**** fatality***

Subsequently, the respondent was asked how long the injured player had to wait before reaching the hospital. The majority (80 %; n=55) of ASCIs were treated in hospital within the recommended four-hour period (Table 9). Of the four players who took longer than four hours to receive hospital treatment, only one had treatment delayed because of lack of transport. This player had a permanent outcome. In contrast, the other players with an ASCI (n=3) who had delayed treatment (> 4 hours) were delayed because the seriousness of the injury was not apparent at the time of injury. Medical advice was only sought well after the recommended four-hour optimal period and yet all three of these injured players had non-permanent outcomes. The difference in outcome between the players that did and did not receive treatment within four hours was not significantly different (p=0.268) (Table 9).

Table 9: Time before being taken to hospital by players who sustained an acute spinal cord injury (ASCI)

	Not provided	Not Permanent	Permanent
<4 Hour	*0%*	45% (n=25)	55% (n=30)
>4 hours	*0%*	75% (n=3)	25% (n=1)
Not applicable	*0%*	100% (n=1) *	100% (n=1) *
Not provided	*(n=2)*	*(n=1)*	*(n=5)*
Total	**3% (n=2)**	**43% (n=30)**	**54% (n=37)**

**One fatality and one player outside of South Africa*

Spineline was not contacted in 52 % (n=36) of reported ASCIs (Table 10). The commonest reasons provided for not using the Spineline number were: there was no knowledge of Spineline/Spineline not known (n=11); the severity of the injury was not recognised (n=6); In three cases, other emergency services were called as first responders.

Of the 19 cases (28 %) where Spineline was contacted, 63 % (n=12) had permanent outcomes and 37 % (n=7) non-permanent outcomes. Fifty % (n=18) of cases that did not contact Spineline had a permanent outcome. However, this difference in outcomes in those who did and did not contact Spineline was not significant (p=0.260). Data were not provided in 13 case. (19 %).

Table 10: Outcome when Spineline contacted in players who sustained an acute spinal cord injury (ASCI)

	Not provided	Non-Permanent	Permanent (%)
Yes	*0%*	37% (n=7)	63% (n=12)
No	*0%*	50% (n=18)	50% (n=18)
Not applicable	*0%*	0%	100% (n=1)*
Not provided	*(n=2)*	*(n=5)*	*(n=6)*
Total	***3% (n=2)***	**43% (n=30)**	**54% (n=37)**

**One player was outside of South Africa when the injury occurred*

None of the players who were removed from the field with an ASCI had been injured or received treatment for a neck injury before the ACSI injury. One player however, reported that he had hurt his neck in a previous game.

Appendix C – Ethics approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
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11 November 2016

HREC REF: 793/2016

Prof M Lambert
Human Biology
Sports Science Institute

Dear Prof Lambert

PROJECT TITLE: IMMEDIATE POST CATASTROPHIC INJURY MANAGEMENT IN RUGBY UNION: DOES IT HAVE AN EFFECT ON OUTCOME? (MPhil candidate- Dr J Suter)- LINKED TO 438/2011

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the HREC has **formally approved** the proof of concept for phase 1 of the above-mentioned study.

Approval is granted for one year until the 30th November 2017.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student Dr J Suter will be involved in this study.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

Signed by candidate

Signature removed

CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI),and Declaration of Helsinki (2013) guidelines.
The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.