An evaluation of emergency field side care following implementation of the BokSmart program for rugby in South Africa

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By

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List of Acronyms and Abbreviations

AED	Automated external defibrillator
AHA	American Heart Association
AHPCSA	Allied Health Professions Council of South Africa
ALS	Advanced life support
ASCI	Acute Spinal Cord Injury
ASIA	Acute Spinal Cord Injury Association
BLS	Basic life support
BP	Blood pressure
CBPJPF	Chris Burger Petro Jackson Players' fund
CCR	Canadian C-spine Rule
CI	Confidence Interval
CPR	Cardiopulmonary Resuscitation
Dr	Doctor
ENT	Ear, nose and throat
ft	feet
HEMS	Helicopter emergency medical services
HPCSA	Health Professions Council of South Africa
IOC	International Olympic Committee
ITLS	International Trauma Life Support
IV	Intravenous
m	metre
MACE	Major Adverse Cardiovascular Events
MVC	motor vehicle collision
NEXUS	National Emergency X-radiography Utilization Study
PDP	Professional driving permit
SARU	South African Rugby Union
SANC	South African Nursing Council
SCA	Sudden Cardiac Arrest
SCAT	Sports concussion assessment tool
SDG	Sustainable Development Goals
SICM	Serious Injury Case Manager
SMR	Spinal motion restriction

TBI	Traumatic Brain Injury
WR	World Rugby

Abstract

Introduction

Despite the varied health and social benefits of participating in sports, catastrophic injuries associated with rugby such as those of the spinal cord, brain, and cardiovascular system are rare but can be permanently debilitating or even fatal. To improve injury prevention and surveillance of catastrophic injuries the Chris Burger Petro Jackson Player Fund and South African Rugby Union implemented the BokSmart programme in 2011. The aim of this study is to assess and compare how emergency field side care was affected.

Methods

This observational and descriptive study collected data from the entire Chris Burger Petro Jackson Player Fund catastrophic injury database (n=147) between 2008 and 2019. The study was divided into three parts to describe and analyse: i) the epidemiology of catastrophic injuries in rugby over time, ii) immediate post-injury management and association with player outcomes, and iii) emergency care personnel levels and association with immediate post-injury management. Comparisons were made throughout between pre- and post-implementation of the BokSmart programme.

Results

There was a significant decrease in the distribution of catastrophic injuries between pre- and post-implementation of the BokSmart programme. Similarly, there was a significant decrease in the mean number of acute spinal cord injuries per year in the post-implementation period. The incidence of injuries occurring during high-impact scrums also substantially decreased. Post-implementation there was an increase in the proportion of incidents where first on-field medical support were registered medical care professionals. Injured players were also more likely to receive care that adhered to the BokSmart guidelines post-implementation; however, this ultimately made no difference in the outcome of acute spinal cord injuries and saw a decrease in the use of external resources like Spineline.

Conclusion

There has been a marked decrease in the mean number of catastrophic injuries per year following the implementation of the BokSmart programme, especially the proportion of acute spinal cord injuries following scrum law changes. This indicates that the BokSmart programme had a positive effect on emergency field-side care through decreasing catastrophic injuries from scrums, increasing the proportion of registered medical care professionals providing field-side care, and improved adherence to the BokSmart serious injury protocols. However, despite improved adherence, outcomes from acute spinal cord injuries have not improved. As there is little to no impact on the outcomes of spinal cord injuries due to the nature of the injury, a shift in focus towards prevention of catastrophic injuries and corresponding law changes should occur. The implementation of the BokSmart programme has shown to be effective through its educational programmes, injury surveillance, management, and reporting guidelines, to not only improve and optimise emergency field-side care, but also to reduce the incidence of catastrophic injuries across all levels of play in rugby.

Chapter 1: Introduction

1.1. Background

Participating in sport is an integral part of many people's lives as a means to maintain health and includes an element of social participation. Current physical activity guidelines for the general population recommend that adults perform at least 150-300 minutes of moderate-intensity exercise per week, together with muscle-strengthening activities, to improve their health status (1). Participation in sport is one way to achieve the physical activity targets and provides benefits for mental health and wellbeing, including emotional and cognitive benefits (2,3). Health benefits include a decrease in the risk of chronic diseases such as obesity, heart disease, stroke, diabetes, and cancer (3). As such, the United Nations have stated that sport plays a major role in achieving the third Sustainable Development Goal (SDG) of good health and wellbeing (4,5). The SDGs were developed to promote fair and sustainable health throughout the world in all communities (5).

1.1.1. Participation in sport is associated with an increased risk of injury

Despite the benefits of participation in sport, there are associated risks, including an increased risk of injury and, subsequently, an increased burden on the health care system; increasing direct costs (medical care) and indirect costs (long-term impacts such as the ability to work) (6). In addition to an increased risk of further injury, injuries may result in long-term health complications, such as osteoarthritis, which will reduce daily activity, productivity, and ultimately the quality of life (6).

A sports injury is defined as "tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy" (7). Injuries can be classified as medical attention injuries, time-loss injuries, or catastrophic injuries (8). Medical attention injuries are injuries that result in a player receiving medical attention (9). A time-loss injury is defined as "an injury that results in a player being unable to take a full part in future training or match play" (9). Catastrophic injuries are injuries that are fatal or, if non-fatal, result in severe disability and neurological impairment including acute spinal cord injuries (ASCI), traumatic brain injuries (TBI), and major adverse cardiovascular events (MACE) (8). The South African Rugby Union (SARU) defines a serious and/or

catastrophic injury 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”(10).

Sports injuries occur frequently and often require emergency medical care. Although serious, catastrophic injuries are rare, appropriate and timely field-side emergency medical care is even more critical in these cases to ensure the best possible outcomes following an injury (11,12). Emergency medical care in South Africa must be provided in accordance with the regulations of the Health Professions Council of South Africa (HPCSA) and the governing bodies of the relevant sports.

1.1.2. Serious and catastrophic injuries in Rugby Union

In a study by Hulteen *et al.* (2017), investigating the most popular sports globally amongst adults, adolescents, and children, it was found that soccer, rugby, netball, and field hockey ranked in the top ten sports played in Africa (13). Rugby became a professional sport in 1995 and is played in various formats (8). When it is played with 15 players per side it is known as Rugby Union, hereafter referred to as rugby (14). In 2019 it was estimated that globally there were more than nine million rugby players in 133 countries (15), with approximately 600 000 junior level players and 122 000 senior level players in South Africa (16). Injuries occur three times more often in rugby than in other contact sports (8).

The governing body of rugby union in South Africa is the SARU. In an effort to improve the safety of rugby and protect players, SARU developed the BokSmart National Rugby Safety Programme in collaboration with the Chris Burger Petro Jackson Players’ fund (CBPJPF) (17). The BokSmart programme was widely implemented in South Africa in 2011 to educate all stakeholders on better injury prevention, injury surveillance, and management. This programme details the exact requirements for the management and reporting of injuries in both professional and junior rugby, and specifically provides guidelines to minimise the risks involved for participants at all levels of play (16). The guidelines include the serious injury protocol (18) which details the exact reporting that must occur in the event of a serious injury. Following this, a serious injury report (19) is completed and the information is collated in the CBPJPF/ SARU catastrophic injury database. This has been introduced in an effort to expand and improve injury surveillance.

1.1.3. Motivation for this research project

To better understand the environment surrounding catastrophic injuries in rugby, it is pertinent to undertake a detailed analysis of the immediate post-catastrophic injury management of cases, adherence to the BokSmart serious injury protocols, and any association of these factors with injury outcome. In addition, an analysis of the management process on-field including the personnel present, the transport from the field to medical centre, time taken to receive definitive care, and whether these factors aligned with best possible clinical practice expectations and the protocol outlined by BokSmart would be beneficial.

1.2. Study aim and objectives

This study aims to assess how emergency field-side care was affected following the full implementation of the BokSmart program in 2011 in South Africa, and to compare catastrophic injury epidemiology, treatment, and emergency care personnel profiles before and after its implementation.

The objectives in reaching this aim are:

1. To investigate the epidemiology of three catastrophic rugby injury categories (ASCI, TBI and MACE) in South Africa and analyse this for differences in the BokSmart pre- and post-implementation periods (Chapter 4).
2. To describe and analyse immediate post-injury management and its association with player outcomes following catastrophic rugby in South African rugby between 2008 and 2019. (Chapter 5).
3. To describe and analyse emergency care personnel levels and its association with immediate post-injury management in South African rugby (Chapter 6).

Chapter 2: Literature Review

2.1. Introduction

Rugby is an extremely popular contact sport worldwide, particularly in South Africa (16). In rugby, injuries occur three times more often than in other contact sports (8), and it has been found that rugby has the highest risk for acute spinal cord injuries (ASCI) (20) and head injuries, such as concussion (21). Although catastrophic injuries are rare, they do still occur, often with devastating consequences for the injured individual and their families. In addition, these injuries have an impact on the health care system (22). Optimal field-side injury management is important in the event of a catastrophic injury as this may influence long-term outcomes (23).

The published academic and grey literature pertaining to injury incidence, prevention, and management in Rugby Union will be reviewed below. Firstly, the definition of sports injury, specifically catastrophic injuries as adopted in the literature, will be discussed, followed by a brief review of injury incidence and epidemiology in rugby. To better understand the environment pertaining to rugby injuries in South Africa, it is also pertinent to review the available guidelines and regulations relating to field-side emergency medical care in South Africa and the procedures to follow in the event of injuries on the rugby field.

2.2. Injury definition

There are many definitions of a sports injury with multiple factors influencing how an injury is classified. The International Olympic Committee (IOC) Consensus statement of 2020 concisely defines a sports injury as "…tissue damage or other derangement of normal physical function due to participation in sports, resulting from rapid or repetitive transfer of kinetic energy" (7). This definition has been adopted by SARU and thus will be used for this study. Injuries can be acute, with a large instantaneous transfer of kinetic energy, or more chronic, overuse injuries that develop over time with repetitive use (7). Injuries can be classified as medical attention injuries, time-loss injuries, and catastrophic injuries (8). Injuries can be further classified by what type of treatment they received, whether the injured player could continue to participate in matches and training events and whether there were severe health

consequences following the injury. Medical attention injuries are defined by the IOC as “an injury that results in a player receiving medical attention” (9), and a 2018 systematic review by Yeomans *et al.* defined these as “injuries necessitating on-field treatment or removal from the game” (24). A time-loss injury is defined by the IOC as “an injury that results in a player being unable to take a full part in future training or match play” (9), and in other studies, it has been defined as “injuries necessitating at least one day’s absence” (24). In non-catastrophic injuries, these differences in injury definition result in difficulty comparing injury rates across settings, sports, and grades of play.

Catastrophic injuries are injuries that are fatal or, if non-fatal, result in severe disability and neurological impairment including ASCI, traumatic brain injuries (TBI), and major adverse cardiovascular events (MACE) (8). SARU defines a serious and/or catastrophic injury 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”(10).

2.3. Injury incidence and epidemiology

Injuries causing a player to seek medical attention are common in contact sports such as rugby, football (known as soccer in South Africa), netball, and hockey. While participants readily come into bodily contact with one another (25,26), serious and catastrophic injuries are rare, even in contact sports. However, in rugby, injuries occur at a rate three times higher than in other contact sports (8).

In various reviews of the incidence of catastrophic injuries at international professional level including the Rugby World Cup, the average incidence of all types of injuries ranged between 66 and 98 injuries per 1000 player match hours (Table 2.1) (8,27–30). Interestingly, the Welsh professional team had double the rate of injuries in a two-year period compared to other international teams (30). In the Currie Cup Premiership, a professional provincial level rugby competition in South Africa, 2018 injury surveillance reported an injury rate of 82 injuries per 1000 player hours, which was similar to the international rate of 81 injuries per 1000 player hours (31). In a review by Viviers *et al.* (2018) between 2007 and 2017, it was reported that more injuries happen during rugby matches as opposed to during training (8).

Table 2.1 Injury incidence at international level during matches and training sessions

	Year/s	Number of injuries per 1000 player hours		Source
		Matches	**Training**	
International premier league	2007-2017	81	3	Viviers *et al.* 2018 (8)
Australian Super Rugby	2014	66	2	Whitehouse *et al.* 2016 (27)
National Welsh Professional team	2012-2014	180	5	Moore *et al.* 2015 (30)
Rugby World Cup	2003-2011	90-98		Moore *et al.* 2015(30)
Rugby World Cup	2015	90		Fuller *et al.* 2017 (28)
Rugby World Cup	2019	79		Fuller *et al.* 2020 (29)

In reviewing the most injured anatomical regions it was found that the head, neck, and lower limbs are most often injured. In all Australian teams participating in the Super Rugby Union competition in 2014, it was reported that the most frequently injured body part was the lower limbs followed by the head and neck (27). Whereas the national Welsh professional male rugby team surveillance reported that the most commonly injured body part was the shoulder followed by the lower limb and then the head (30). Surveillance from the 2003, 2007, and 2011 Rugby World Cups found that the head and face were the anatomical area most injured followed by lower limb and muscle injuries (28,30). Injuries to the head and face were also found to be the most common injury site in the 2019 Rugby World Cup (29). In South Africa, surveillance of various Currie Cup Premiership competitions found that the head was the most commonly injured site followed by ligament and muscle injuries (31–33).

The scrum was considered the most dangerous phase of play associated with injury until 2007 when the International Rugby Board (now World Rugby) modified the scrum laws (34). Whitehouse *et al.* (2016) showed that most injuries reported were as a result of being tackled, resulting in more lower limb injuries and head injuries (27). In a three-year study of the National Welsh professional male team by Moore *et al.* (2015), the tackle was reported to be the event causing the most injuries (30). Similarly for the Rugby World Cups (2003-2019) collisions characterised by contact with other players or the playing surface (35), and tackling, a form of collision (35), were recorded as the events causing the highest injury rates (28,29). The 2018 and 2019 injury surveillance of The Currie Cup Premiership competition reported the tackle being the event that caused the most injuries, 21 injuries per 1000 player hours

(31,33). However, in the 2020/2021 injury surveillance of Super Rugby and Carling Currie Cup Premiership competition in South Africa, the collision was the event that caused the most injuries, and the tackles carried the highest severity of injuries reported (36).

Injury rates in youth players show a large degree of variability. In a 2011 systematic review, by Bleakley *et al.* (2011) it was reported that rugby injury rates in adolescents ranged between 28 - 130 per 1000 match hours using the "medical attention" definition (37). In a later systematic review by Leahy *et al.* (2019) undertaken in 2018, it was found that injury incidence rates of school level rugby varied from 24 - 130 injuries per 1000 hours (38). In two reports, a surveillance report of English youth competitions in 2013 and a study of elite English schoolboy rugby participating in academy matches, injury rates were between 34 - 35 injuries per 1000 match hours (39,40)

In South African studies conducted by Constatinou *et al.* (2015) and Starling *et al.* (2019) at youth rugby festivals between 2010 and 2018 reported injury rates of 41-57 injuries per 1000 playing hours in adolescent participants (9,41). The annual injury surveillance of a 2019 South African Boys Youth Week reported higher time-loss injury incidence in players under 16 years of age as compared to younger players (42). Similarly, a higher injury rate was reported for under 18 years of age players compared to younger players in an injury surveillance of a 2019 South African Girls Youth Week (32). Youth injuries appear to be more prevalent in South Africa as compared to England.

Similar to professional rugby players, youth players had similar patterns of injury with regard to the anatomical region most frequently injured (40). Barden *et al.* (2018) found that in elite English schoolboy rugby participating in academy matches, it was reported that the head and face were the most common injury site (40). In the 2019 Youth Week tournaments it was reported that central nervous system injuries and the head and neck were the most recorded injuries followed by joint and ligament injuries in the girls' and boys' tournaments (32,42).

A systematic review of school level rugby, undertaken in 2018 by Leahy *et al.*, found the tackle to be the most common injury causing event (38). In elite English schoolboy rugby, Barden *et al.* (2018) found that the tackle was the most common event causing injuries in players participating in academy matches, (40). The players participating in the 2019 Youth Week

tournaments and performing the tackler role were reported to have the highest incidence of injury for both tournaments (32,42). Playing positions for injured players differed between girls and boys. In the girls' tournament, scrum halves and fly halves had the highest incidence of injury whereas in the boys' tournament, it was seen that props and locks had the highest incidence of injury (32,42).

The injury incidence rate in international youth Rugby Union is lower than in professional levels of play, however, the head and face are still the most common site of injury with the tackle being the most common event causing injury for all age groups. Similarly, junior players (under seven to under-19 years of age groups) suffer significantly lower catastrophic injury rates than senior players (older than age 19) (43). These injury rates are comparable to other sports such as field hockey (44). Badenhorst *et al.* (2017) reported an average annual incidence rate of catastrophic injury (ASCI and TBI) of 4 per 100 000 players in South African Rugby Union between 2008 and 2014 (45). Over half (54%) of the ASCIs were fatal or sustained permanent disability (45). Even though it is clear that there is a relatively low rate of catastrophic injury in this popular contact sport, it is estimated that over half of these injuries were preventable (46,47).

Overall matches have a higher injury rate than training sessions at all levels of play, specifically when matches are part of tournaments or competitions. Injury rates vary based on the level of play and age group; however, the head and lower limb are consistently the most frequently injured anatomical areas. Concussion was repeatedly reported as the most common injury at all levels of play. Since scrum law changes, tackling the opponent or being tackled has consistently been reported as the event that causes the most injury.

2.4. Field-side management of sports injuries in South Africa

There is a paucity of published literature describing the field-side management of youth sports injuries in South Africa, however, there is a wealth of literature relating to field-side management of specific injuries in adult sports. It has been found that proper care of the injured player at the scene or field-side allows for more appropriate interventions at the emergency department and could minimise the disastrous outcomes of catastrophic injuries (23).

An example of a successful injury management approach in the South African setting is the SARU BokSmart programme. In an effort to minimise injury rates, SARU, in collaboration with the CBPJPF, implemented the BokSmart programme in 2011. The programme was designed to provide coaches and referees with education on injury prevention training and to improve injury surveillance, identification, and reporting, in the format of a course (48,49). It is a compulsory course that requires all referees and coaches to participate in. This BokSmart programme details exact requirements for the management and reporting of injuries in both professional and amateur rugby at the senior and junior levels, and specifically provides guidelines to minimise the risks involved for participants at all levels of play (50). These guidelines are freely available on the South African Rugby website, the BokSmart website, and the SuperSport website (Table 2.2). To ensure that implementation of the guidelines was occurring, BokSmart also provided an audit tool document to be used by schools, clubs, and rugby bodies. This tool is submitted annually and may be accompanied by random site visits by appointed BokSmart auditors (51).

2.4.1. Grade of play

SARU and BokSmart describe the level of play by a colour differentiation: green; gold and gold+. Green guidelines are utilised in the following playing situations: normal school rugby matches, normal club rugby matches, community rugby, and all sevens format matches at school, club, or community level. Gold and gold+ are the guidelines utilised at all elite rugby levels. Gold will include professional tournaments, interprovincial matches, community cups, varsity cups, SARU youth weeks, schoolboy festivals, classic clashes, and all professional Seven-a-side matches and tournaments. Gold+ will include all international level matches and tournaments, as well as the Currie Cup premiership and Super rugby contest (52). Under each of these categories the specific requirements for equipment, ambulance and personnel availability are detailed.

2.4.1.1. Equipment requirements

BokSmart recommends a minimum list of equipment available at the field side and in the medical tent/ room. The equipment available should be in accordance with the qualifications of the personnel that are present at the various levels of play (52). For all levels of play, spinal motion restriction (SMR) equipment, the BokSmart concussion guide, the Sports Concussion

Assessment Tool 5th edition (SCAT5), and a first aid bag are required. For gold and gold+ levels, additional equipment is required such as basic life support (BLS) and advanced life support equipment (ALS) and a golf cart (52,53).

2.4.1.2. Ambulance availability and access

BokSmart recommends that an ambulance should ideally be available at the playing venue. If this is not possible an ambulance should be on standby to transport injured players to the hospital. The *Safety in the playing environment* document recommends that an ALS ambulance should be on site for gold+ level. For gold level, a BLS ambulance should be on site and for green level, access to emergency medical services should be available (52). The document additionally states that regulations in the *Public Safety Act of South Africa* (54) must be adhered to.

For SARU tournaments, the *Participant Medical and Safety measures* document states that there should be a second ambulance on stand-by in addition to the dedicated ambulance at the event. It also states that ambulances present must be registered as per various South African Acts as ambulances and be fully equipped (53).

Table 2.2 Guidelines, protocols, and policies on injury management in rugby in South Africa

Title	Link
Acute Spinal Cord Injury Association chart	https://bit.ly/3WcYRGc
BokSmart Evidence-Based Guidelines for Medical Assessments	https://bit.ly/3BVkxhZ
BokSmart General Medical Assessment form	https://bit.ly/3FKgy9g
BokSmart Management of Rugby injuries	https://bit.ly/33lo3nG
BokSmart Medical Management of Suspected Serious Acute Spinal Cord in Injuries in Rugby Players	https://bit.ly/3YFHkIn
BokSmart Safety in the playing Environment	https://bit.ly/34X38If
BokSmart Serious Injury Protocol and questionnaire	https://bit.ly/3KjOpaC
Early Treatment of Soft Tissue Injuries	https://bit.ly/3jjWH9j
New Treatment Modalities in Soft Tissue Injuries	https://bit.ly/3v7PqvV
On-field airway management techniques	https://bit.ly/3v8ZSmY
Pre-participation Screening of Players and questionnaire	https://bit.ly/3vcpYoQ https://bit.ly/3G6W63M
Protective Equipment in Rugby	https://bit.ly/3nxSkqt
South African Rugby Union Protocol for Medical Personnel Entering the Field of Play	https://bit.ly/3WfiOMJ
South African Rugby Union Tournament Medical and Safety Minimum Standards	https://bit.ly/3KdMiF9
The 4-6-hour window of acute spinal cord injury treatment	https://bit.ly/3YHPdwQ

Accessed May 2022

2.4.2. Medical care personnel

2.4.2.1. Minimum qualifications and registrations of personnel

In South Africa, all medical care providers are required to register with the HPCSA (55). Emergency medical services personnel are limited by a scope of practice which is governed by the HPCSA (56). There are various levels of qualification, from basic to advanced life support, with different scopes of practice and capabilities and these will dictate what procedures, skills, and medications may be carried out or given to a patient (56). The BLS scope is the most

limited scope of practice with predominantly non-invasive skills and a small number of medications including oxygen, aspirin and nebulisation medications (56). The intermediate life support (ILS) scope of practice has more invasive skills, such as intravenous (IV) therapy, and a larger number of medications, including adrenalin, nebulisation medications and aspirin (56). The ALS scope of practice has the largest number of skills; including intubation, suturing and IV therapy; and medications such as advanced cardiac life support medications, rapid sequence intubation agents and analgesic medications (56).

While medical care providers are required to register with the HPCSA, lay rescuers are not required to register with a professional body. First aid course provision is governed by the Department of Employment and Labour and the various Quality Assurance Bodies (57). Thus, first aiders must be trained through an accredited provider for the certificate to be valid and are considered lay rescuers. While lay rescuers do not have a scope of practice, they are bound by a *duty to care* and only perform skills that they have been found competent in (58).

According to the *Safety in the playing environment* guidelines for green level matches a trained first aider is required. However, at gold and gold+ levels, a larger complement of staff is required with a minimum of a match doctor, ILS and ALS emergency medical services staff, and helicopter emergency medical services (HEMS) staff on standby (52). All referees and coaches must be BokSmart certified and, if possible, first aid trained (52). The BokSmart Rugby Medic was a short course offered by BokSmart to provide free, acute on-field injury management training to individuals involved in rugby in low-resource communities (50). The BokSmart Rugby Medic certification is not an HPCSA registered professional qualification.

For SARU tournaments, the *Participant Medical and Safety measures* document clearly indicates that all medical personnel must have current registrations with the HPCSA Professional Board of Emergency Care Practitioners (53). Additionally, all crew members who will be driving an ambulance must be in possession of a valid professional public driving permit. With regards to medical doctors, physiotherapists and biokineticists, all practitioners must be registered with the HPCSA under their respective professional boards. Additionally, physiotherapists and biokineticists must have a valid first aid qualification (53).

2.4.2.2. Number of personnel required

BokSmart recommends that for green level matches "one or two persons suitably trained in emergency field side care (a trained first aider or paramedic)" are required (52). They also recommend that in low-resource communities a BokSmart Rugby Medic may be utilised but, if possible, should not replace a first aider or paramedic.

For SARU tournaments, the *Participant Medical and Safety* measures document states that there should be a tournament doctor, a registered nursing sister, four basic life support medics per field, one advanced life support practitioner per venue, ambulance crew comprising of one intermediate life support and one basic life support practitioner on site, a standby ambulance crew to replace the on-site crew in the event of emergency transportation and emergency medical flight staff on standby (53).

2.4.2.3. Communication protocols

BokSmart's *Safety in the Playing Environment* document simply outlines that the highest qualified medical staff member should take responsibility for communicating with the relevant entities associated with further medical care and transportation of injured players (52). This communication should follow the *Serious Injury Protocol* which specifically states that Spineline should be contacted (10). Spineline is an emergency teleconsultation service operated by the private ambulance service ER24 and allows for road transportation of injured players who do not have medical aid nor the funds to pay for private transportation (59)

2.4.2.4. Emergency action plans and documentation

BokSmart's *Safety in the playing environment* recommends that a documented emergency action plan should be available detailing the processes and procedures to be followed in the event of a potentially catastrophic injury. This document includes the layout and access to the facility, what equipment is available, the internal and external support personnel, the communication protocol, and details of any follow-up required following a catastrophic injury (52).

2.4.2.5. Pre-screening of players

BokSmart recommends pre-participation screening of rugby players by coaches, based on internationally accepted medical standards (60). This guideline states that the practice of pre-

screening is not done as often as it should be, and they have therefore designed a simple questionnaire for coaches to complete aiding in the identification of any potential medical conditions that may put the player at risk while participating in rugby (61). Questions include asking the participant if they have any specific medical conditions, allergies, experienced shortness of breath or if they have had any cardiovascular investigations (60).

The questionnaire has clear guidelines for coaches:

> "A positive answer (YES) to any of the questions requires the player to be followed up by a medical professional associated with the school, club, or union, or recommended by SARU. Written medical clearance should be received for the specific condition highlighted before participation in any match or training session."

Additionally, BokSmart has created a *General Medical Assessment form* for medical practitioners to complete to ensure player safety while participating in the sport and to help guide treatment in the event of a medical emergency or injury (62). This document includes specific cardiac and musculoskeletal screening tools. The International Rugby Handbook does not have any specific guidelines with regard to medical screening of players (63).

2.5. Specific injury protocols and procedures for catastrophic injuries

BokSmart has a S*erious Injury Protocol* in place. The document defines a serious injury 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 emergency care centre" (10). This protocol states the exact steps to follow and who to report to in the event of a serious injury. It additionally outlines the follow-up post injury. Blood injuries and concussions are specifically discussed in the *Participant Medical and Safety measures at SARU Tournaments* (53). This document references the World Rugby Laws for further information (63).

2.5.1. Traumatic brain injuries

There are several types of brain injuries including haemorrhage, concussion, and contusions (64) which fall into two categories of brain injury: primary and secondary. The primary brain injury is the initial insult to the brain usually resulting from a *coup- contrecoup* event, while a

secondary brain injury is as a result of hypoxia and decreased cerebral perfusion (64). The identification of concussion and brain injury is reliant upon a good assessment of the patient and an understanding of the mechanism of injury. To effectively identify a concussion the SCAT5 should be utilised (65). The goal is to recognise the concussion or TBI and remove the player from the field (66). This tool includes an on-field or immediate component assessing the presenting signs and symptoms, a series of memory questions, and a measurement of the Glasgow Coma Scale (GCS). This is followed by a later assessment of the signs and symptoms, a neurological and cognitive screening, and a decision on return to play (67).

Subsequently, the injured player should be assessed, and symptomatic treatment given to prevent secondary brain injury. If the player presents with a more significant brain injury, then local protocols should be employed, including SMR, and the injured player should be transferred to a trauma centre immediately for further treatment (67). Management of TBI should include neuroprotective strategies such as management of hypoxia and hypocarbia, hypoglycaemia, and hypotension (systolic blood pressure less than 110mmHg) (64,68). Other techniques may include optimising venous drainage from the head by employing a head up at 30^{o} technique to reduce the intracranial pressure (69). In a review, by Morris *et al.* (2014), of American athletes sustaining TBIs, it was reported that early field-side care, the decision to transport the injured athlete, and the choice of destination may improve the outcome of this catastrophic injury and reduce morbidity and mortality (12).

With regards to TBIs, management is aimed at reducing the risk of secondary brain insult by optimising ventilation and perfusion (70). Another critical aspect of the management of TBI is recognition and it has been found that sports participants who are concussed and do not leave the field to seek medical care may receive a second insult which can result in more serious sequelae; including chronic traumatic encephalopathy and neurodegenerative diseases (71). A study evaluating the factors associated with delayed recovery in athletes with concussion showed that early diagnosis and intervention are associated with shorter recovery times and earlier return-to-play in concussed sports participants (72).

BokSmart has implemented a blue card that may be issued by the referee in the event of a player appearing to have sustained a concussion or traumatic head injury. The blue card has 11 signs and symptoms that allow for the recognition of concussion and the removal of the

player from the field with medical assessment and treatment following the removal of the injured player (73). It is recommended by BokSmart that for players under the age of 18 years, there should be a two-week rest period followed by a graduated return to sport, while players older than 19 years of age should have a minimum of a one-week rest period followed by the graduated return to sport (74). The graduated return to sport is a phased approach to increasing the intensity of physical activity and eventually return to full contact sport (74). Clearance by a medical practitioner is required before the injured player can return to full contact rugby (74).

2.5.2. Acute spinal cord injuries

ASCIs can be life-threatening or have life-changing consequences such as paralysis. Managing an ASCI can be difficult, but the main goal is to prevent any further spinal injury by preventing movement of the spinal column (64,75). Good initial medical treatment and transport to an appropriate facility will improve the outcome of various injuries, most especially ASCI (76). However, some traditional spinal immobilisation techniques may cause adverse events following an ASCI (77). There is emphasis that preparation and training of medical teams is the most important factor. Evidence-based and contextually appropriate injury management protocols are therefore vital to optimising field-side injury care, minimising the long-term consequences of serious injury, and improving players' quality of life post-injury (78).

Spinal motion restriction (SMR) guidelines often begin with the decision to apply SMR, which can be done using a decision tree such as the one outlined by International Trauma Life Support (ITLS) organisation (Figure 2.1) (64). Decision trees determine whether the mechanism of injury is high risk, if the patient has any abnormal findings related to the spinal column (such as spinal pain and tenderness, anatomic deformity, or neurological impairment (75,77), and whether the patient is reliable or not. Reliability of the patient refers to whether the patient can communicate effectively and whether or not they are under the influence of any intoxicating substances (77). Based on these findings, it will guide the practitioner on whether to apply SMR or not, however, a high index of suspicion must be observed. The presence of a cervical spine injury can be assessed using validated assessment tools such as the National Emergency X-radiography Utilization Study (NEXUS) (Figure 2.2) or Canadian C-spine Rule (CCR) (Figure 2.3) (75,77). However, these were initially designed to determine

whether or not a patient should have an in-hospital radiological investigation after sustaining an ASCI (75,79).

In the pre-hospital setting, these tools have been utilised to assist the practitioner to rule out any significant cervical spine injury and assist in the decision of whether or not to apply SMR (77). In South Africa, all practitioners; except basic life support practitioners; are permitted to clear a cervical spine. However, practitioners must err on the side of caution and apply evidence-based SMR techniques (56,79).

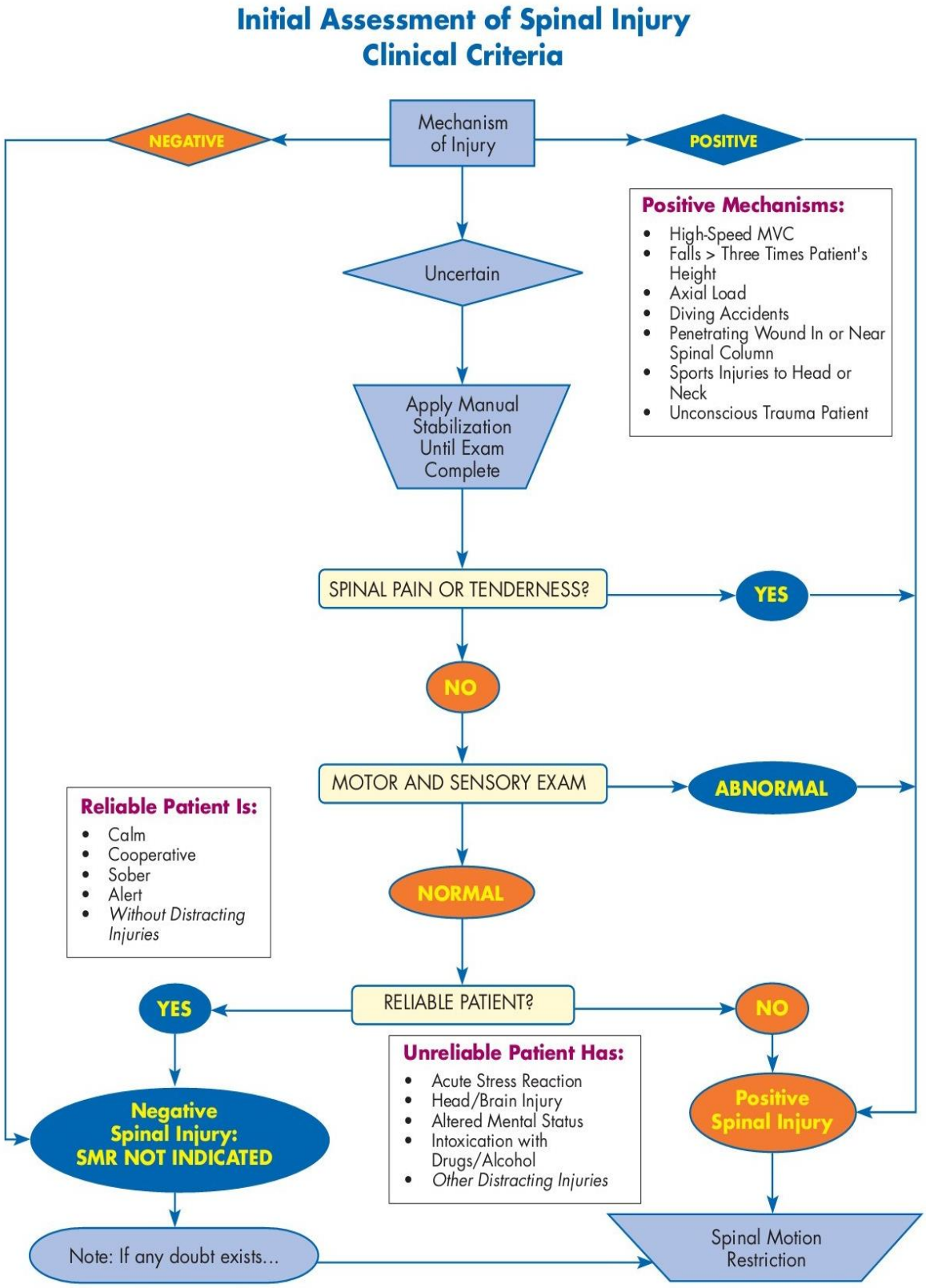

Figure 2.1 Decision tree for spinal motion restriction, *reproduced with permission from International Trauma Life Support, South African chapter* (80).

- MVC: Motor vehicle collision

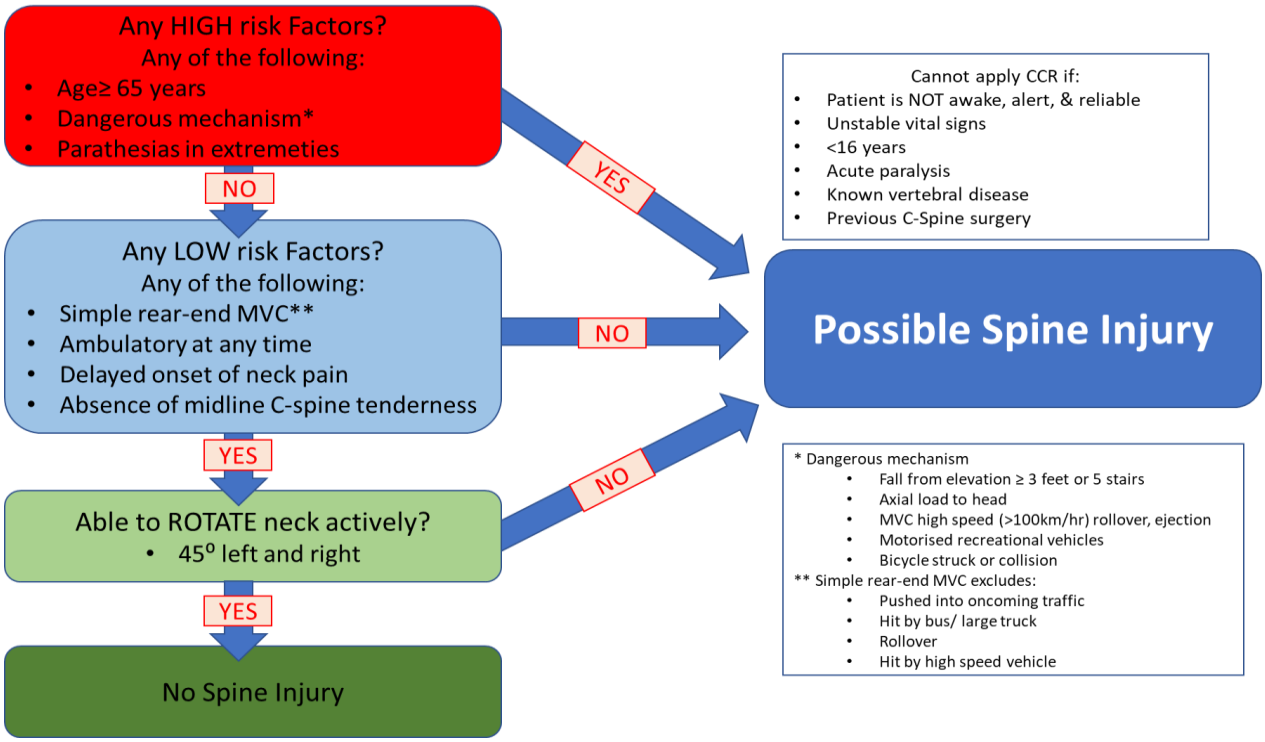

Figure 2.2 Flow diagram depicting Canadian C-spine Rule, modified from International Life Support 7th ed. (64)

- CCR: Canadian C-Spine Rule; C-spine: cervical spine; MVC: Motor vehicle collision

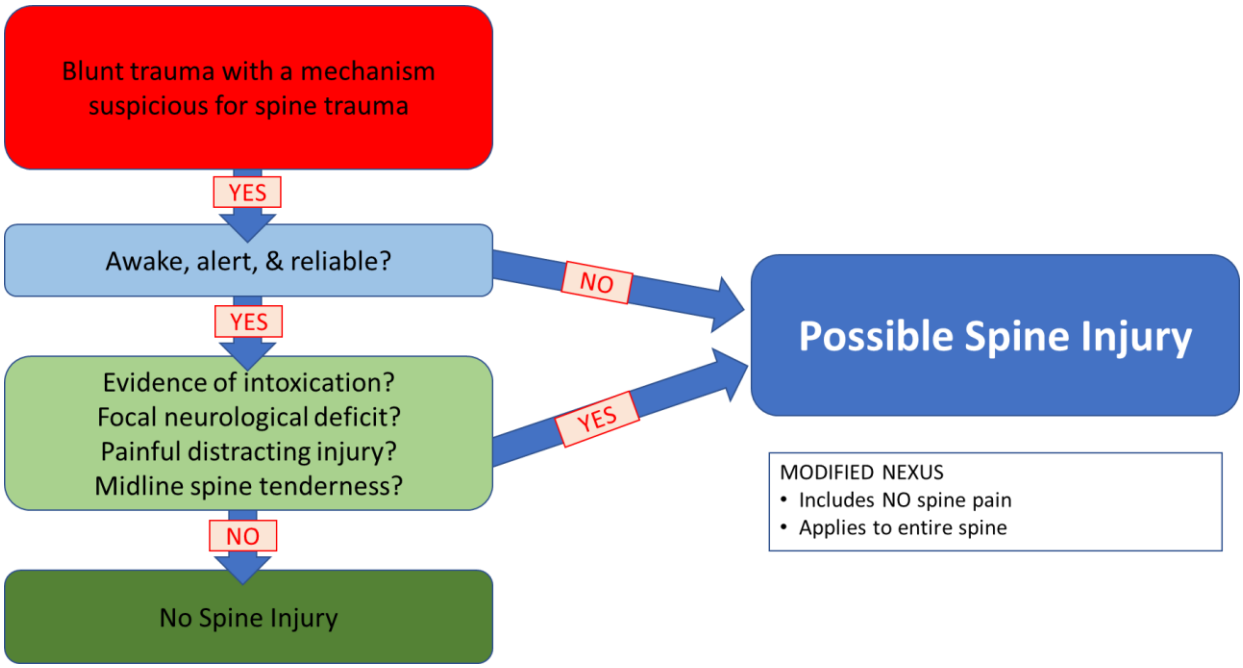

Figure 2.3 Flow diagram depicting National Emergency X-radiography Utilization Study (NEXUS) Rule, recreated from *International Life Support 7th ed.* (64)

Various equipment is required to carry out SMR including a rigid cervical collar, a spider harness, head blocks, and a spine/long board, scoop, or a vacuum mattress (64,75). The BokSmart *Medical management of suspected serious acute spinal cord injuries in rugby players* guide supports this practice on the field (81).

It should however be noted that there is controversy surrounding the use of some of these items, specifically the cervical collar and spine board (77,82,83). The cervical collar should ideally be avoided in the pre-hospital setting as there are several risks associated with its use (77). In particular, the possible displacement of upper c-spine injury caused by the collar pushing the head upwards and, in the case of a c-spine injury with a TBI, there is evidence to show that intracranial pressure is increased by the collar (83). Furthermore, the collar has been shown to obstruct venous drainage from the cranium and may cause an airway obstruction (77). Placement of the collar should therefore only be performed by a highly skilled practitioner to minimise movement of the head and neck. ITLS recommends that patients should be carefully evaluated to determine if they meet the criteria for placing a single-use cervical collar and that it should be appropriately sized and correctly placed (84). BokSmart has recommended that the decision to utilise or not utilise the cervical collar remains the decision of the registered medical care professional (85).

The use of a spine board or long board has also caused controversy due to the fact that spine boards have been shown to cause pressure sores, discomfort, and respiratory compromise (77,80). The recommendation is that spine boards should be used for extrication only and the patient moved onto the vacuum mattress or transport stretcher as soon as possible (77). BokSmart recommends that if a firm board is being utilised, a soft, thin intervening mattress should be attached to prevent the development of pressure sores in the injured player (81).

Ideally, the goal of SMR is to limit spinal motion and prevent further injury. Several studies reviewing the care of patients sustaining spinal injuries have shown that poor SMR techniques cause further damage in approximately 25% of the patients reviewed (86). In a qualitative study amongst individuals with rugby-related spinal cord injuries, three key themes were identified as barriers to, or facilitators of, adequate management of these injuries (23). These included the perceived competence and quality of care received by first responders on the field, logistical factors relating to the availability of equipment and patient transport, as well

as the resources available and communication with hospitals and secondary health care providers (23). Although some of these barriers are difficult to control, others can be improved by continuous training of first responders and ensuring effective emergency action plans are in place to streamline the entire process.

2.5.3. Major adverse cardiovascular events

Major adverse cardiovascular events (MACE) may include acute myocardial infarctions, strokes, and cardiovascular mortality (87). Sudden cardiac arrest (SCA) is defined as "an unexpected cessation or severe malfunction of heart function" (66). There are various causes including an underlying cardiac disease, a congenital malformation, *commotio cordis,* or non-cardiac causes such as electrolyte imbalances (66). The American Heart Association (AHA) has several treatment algorithms for managing MACE. The treatment of MACE should follow the AHA's chain of survival which includes activation of emergency response, high-quality cardiopulmonary resuscitation (CPR), defibrillation, advanced resuscitation, post-cardiac arrest care, and recovery (88). The AHA advocates for good chest compressions, early defibrillation, and the removal of reversible causes. Most of the governing bodies for sports in South Africa have aligned their guidance with that of the AHA to produce algorithms for the management of MACE in sports. BokSmart guidelines place substantial emphasis on the early recognition of cardiac arrest and provide infographics following similar flows to the AHA recommendations (89).

Ko *et al.* (2018) looked at the influence of early first responder care in out-of-hospital cardiac arrests (OHCA) while participating in exercise and sport (90). They found that almost half of OHCA that occurred in the presence of a first responder had good neurological outcomes and survival to discharge (90). This shows that having well-trained individuals ready to respond will improve outcomes following OHCA. As an example, in June 2021, a Danish footballer experienced a SCA on the field during a televised match and, due to a quick response from the medical team, survived and regained consciousness before being transported to hospital (91). This event shows that well-trained practitioners with a clear emergency action plan can make a difference in the outcome following a catastrophic injury.

2.6. Catastrophic injury reporting in South African rugby

In order to develop injury prevention programmes and minimise risk in sports, injury surveillance must occur (92). Since 2008, the CBPJPF, in conjunction with SARU, has maintained a surveillance database of Rugby Union catastrophic injury data. In the event of a catastrophic or serious rugby injury in South Africa, the BokSmart *Serious Injury Protocol* (18) is implemented. This protocol provides a list of who to contact, how the incident should be handled, and provides specific forms that require completion. A serious injury report must be completed by the "identified responsible person" (medical personnel) and the referee and be submitted within 48 hours to the serious injury case manager (SICM) (10). This is followed up by the SICM contacting the injured player or the player's family to complete the *Serious Injury questionnaire* (93). This data is then captured in the CBPJPF/SARU catastrophic injury database. Data collected includes the type and severity of the injury with a follow-up one month later in the case of a non-fatal incident. It additionally records what interventions were carried out at the time of injury, the type of transportation, time to definitive care, field and weather conditions, and the use of safety gear. This CBPJPF/SARU catastrophic injury database presents a unique opportunity to examine the relationship between policy, field-side injury management, and outcome following a serious injury.

According to Dr Wayne Viljoen, senior manager of the BokSmart National Rugby Safety Programme, his experience of the BokSmart programme is that it has shown to be effective in reducing catastrophic injury rates in junior rugby players (16) and, more recently, in senior rugby players as well. Previous research by Suter *et al*. (94) described a cohort of 87 catastrophic injuries in SARU between 2008 and 2014 and observed no significant association between immediate post-injury management with ASCI (n=69) outcome at one month. However, there were an additional 60 catastrophic injuries between 2014 and 2019 and this CBPJPF/SARU catastrophic injury database warrants further analysis to determine whether immediate post-injury management has changed since the widespread implementation of BokSmart in 2011, and potentially improved the outcomes of injured players.

2.7. Conclusion

There is extensive published clinical and biomedical literature on how to manage specific injuries. From an emergency care standpoint, there is very little differentiation in terms of the mechanism of injury and the population in which the injury has occurred. Emergency care protocols and guidelines may not always apply to a sports participant who is otherwise healthy, and the mechanism of injury has lower forces involved than other mechanisms of injury such as motor vehicle collisions.

There is evidence that good field-side care, including early recognition and intervention, can improve the outcome of the injury and lessen the burden of morbidity on the individual, their family, and the health care system. It has been stated that good preparation and extensive training are key, and this can be applied by having emergency action plans in place with appropriately qualified health care providers (52). The BokSmart programme has addressed various aspects of field side care and it may be of value to investigate whether the individuals participating in sporting events in various roles are utilising the guidelines put forward by BokSmart and if they have made a difference in the injury outcomes of injured players.

Chapter 3: Methods

3.1. Study aim and objectives

This study aims to assess how emergency field side care was affected following the full implementation of the BokSmart program in 2011 in South Africa, and to compare catastrophic injury epidemiology, treatment, and emergency care personnel profiles before and after its implementation.

In order to achieve this aim, we have addressed the following study objectives:

1. To investigate the epidemiology of three catastrophic rugby injury categories (ASCI, TBI and MACE) in South Africa and analyse this for differences in the BokSmart pre- and post-implementation periods (Chapter 4).
2. To describe and analyse immediate post-injury management and its association with player outcomes following catastrophic rugby injuries in South African rugby between 2008 and 2019. (Chapter 5).
3. To describe and analyse emergency care personnel levels and its association with immediate post-injury management in South African rugby (Chapter 6).

3.2. Study design

This study utilised an observational, retrospective cohort study design using the CBPJPF/SARU catastrophic injury database that is maintained in collaboration with the SARU.

3.3. Study population and sample

The study population was the cohort of South African rugby players who sustained catastrophic injuries while participating in Rugby Union at all levels of play. In accordance with BokSmart guidelines and for the purposes of this study, a catastrophic injury is defined 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”(10). Given the relatively rare nature of catastrophic injuries, the study population (2008 to 2019) comprises 147 cases and were all included in this study.

3.4. Data collection procedures

All 147 cases between 2008 and 2019 were included in the study. Catastrophic injuries were categorised under acute spinal cord injuries (ASCIs), traumatic brain injuries (TBIs) and major adverse cardiovascular events (MACE).

As part of the BokSmart catastrophic injury reporting process, a *Serious injury follow- up questionnaire* (Appendix A) is completed following the provision of informed consent (52) and is completed with the injured player, coach or player's family as soon as possible after the incident (93). One month after the injury has occurred, SICM will perform a follow-up visit with the medical doctor in charge of the case to obtain the final diagnosis of the injured player (20). The SICM will capture the answers from the questionnaire on a centrally controlled CBPJPF/SARU catastrophic injury database.

The questionnaire also includes epidemiological information required by World Rugby in the event of a catastrophic injury (Table 3.1).

Table 3.1 Information categories included in *Serious injury follow-up questionnaire*

Personal details	This component includes demographics of the injured player and specific information about the injured player's usual playing position.
Injury circumstances	This component includes specifics with regards to whether the injury occurred during a match or training session, if the injured player was playing in their usual playing position, the grade of play (school or club or professional level) and whether it was a regular match or formed part of a tournament or league. This component also records whether there was any dangerous play that contributed to the injury and any actions taken by the referee or officiating staff member.
Injury event	In this component, the details surrounding the injury itself are recorded including what phase of play the injured player was partaking in (for example, a tackle or a scrum) and their role in the activity.
Immediate post-injury care	This component explores the care given to the injury player in the period immediately following the injury. It includes details of the personnel treating the injured player, where treatment was rendered (on or off the field), what equipment was used, the time it took for the injured player to be taken to hospital as well

	as the mode of transport and what protective equipment the player was wearing.
Playing conditions	In this component information on the weather, the playing surface and the footwear the injured player was wearing are recorded.
Outcome of the injury	The outcome of the injury is recorded as the final clinical diagnosis including specific clinical grading for each type of recorded injury. For ASCIs, the Acute Spinal Cord Injury Association (ASIA) scale is recorded. For TBIs, the Glasgow Coma Scale (GCS) is recorded. For MACE it is recorded whether the injury was fatal or not. The injured player's medical history is also recorded in this component.

Injury outcome is categorised differently for each type of injury. The outcome of the ASCI had two components analysed: outcome classification (fatal, residual disability and near-miss) and the Acute Spinal Cord Injury Association Scale (ASIA) scale within 1 month after injury. The ASIA scale is divided into three main groupings of impairment: A- complete impairment, B-D incomplete impairment and E- normal (Table 3.2) (95). For TBIs, the outcome was classified as fatal, residual with disability or near-miss. TBI outcomes included the GCS which is an assessment of the level of consciousness (96). It includes three components: motor (up to a score of six), verbal (up to a score of five) and eye-opening (up to a score of four) responses with a score of up to 15 based on the patient's best response (96). For MACE, outcome was categorised as either fatal or non-fatal.

Table 3.2 Acute Spinal Cord Injury Association Scale

Acute Spinal Cord Injury Association scale	Outcome description
A	Complete impairment: No sensory or motor function is preserved in the sacral segments
B	Incomplete impairment: Sensory but not motor function is preserved below the neurological level and includes the sacral segments
C	Incomplete impairment: Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade of less than 3
D	Incomplete impairment: 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

3.5. Data analysis

The 147 injuries were categorised by injury type (ASCI, TBI or MACE). The primary exposure variable was the widespread national implementation of the BokSmart programme and was divided into the pre-implementation (2008-2011) and post-implementation period (2012-2019).

Chapter 4 contains a descriptive analysis of the distribution of all 147 catastrophic rugby injuries by injury type, grade of play at the time of injury, positional grouping, period when the injury occurred and phase of play. ASCIs were further analysed for the anatomical location and the outcome of the injury.

Chapter 5 contains a descriptive analysis of the immediate post-injury management of all catastrophic rugby injuries. First on-field medical support was categorised into registered

medical care professionals and lay rescuers. A registered medical care professional was defined as a practitioner with a professional registration under the Health Professions Council of South Africa (HPCSA), South African Nursing Council (SANC) or Allied Health Professions Council of South Africa (AHPCSA). A lay rescuer was defined as personnel with first aid training or a rugby medic qualification.

Specific variables in line with the *Safety in the playing environment guidelines* were analysed including the application of SMR, oxygen utilisation, whether Spineline was contacted, and the time and transport mode to a medical facility (52). For all ASCI cases (n=105) in which there were less than three missing data points related to immediate post-injury management, a composite Optimal Management Score was calculated. A score of one was allocated for each of the ten elements of immediate post-injury management where care was aligned with the BokSmart *Serious Injury Protocol* and other BokSmart medical directives. Additionally, the outcomes of ASCI cases were analysed against the Optimal Management Score. No Optimal Management Score was calculated for TBI or MACE due to the very small sample sizes.

Chapter 6 contains a descriptive analysis of the first on-field medical support present at the time of the injury and the immediate post-injury management of catastrophic rugby injuries. BokSmart has set out a prescribed minimum standard pertaining to the level of care that should be present for various grades of play. Analysis was performed to determine the adherence to these guidelines. With regards to immediate post-injury management by medical care personnel, the application of SMR, oxygen utilisation, whether Spineline was contacted, the time to transfer injury players to a medical facility and the mode of transportation utilised were analysed. For all ASCI cases in which there were less than two missing data points related to immediate post-injury management, a composite Optimal Management Score was calculated. A score of one was allocated for each of the nine elements of immediate post-injury management where that care was aligned with the BokSmart *Serious Injury Protocol* and other BokSmart medical directives. The outcome of ASCIs was compared across the levels of care present. No Optimal Management Score was calculated for TBI or MACE due to the very small sample sizes.

Frequency data are presented as counts and proportional distributions. If any data were “not provided” or missing, they were excluded from the total. Distributions were compared

between exposure categories (pre- and post-implementation of the BokSmart programme) using a Chi-square test, or Fisher's exact test (n<10) as appropriate. An alpha value of 0.05 was chosen to indicate significance. Odds ratios (and 95% confidence intervals) were estimated using collapsed 2x2 tables where distributions were different between the exposure variable categories. All analyses were performed using XLSTAT (Data Analysis and Statistical Solution for Microsoft Excel, Addinsoft, Paris, France 2021).

3.6. Ethical considerations

Proposals for all analyses included in this study were reviewed and approved by University of Cape Town Human Research Ethics Committee (HREC736/2020, HREC054/2021, HREC 055/2021) (Appendix B). Furthermore, the CBPJPF/SARU catastrophic injury database is a prospective database registered with University of Cape Town Human Research Ethics. Following ethical approval, permission to analyse the CBPJPF/SARU catastrophic injury database was granted by the CBPJPF. Once permission was granted, the authors received a deidentified and password protected copy of the CBPJPF/SARU Database. All information has been treated with strict confidentiality and analyses have been conducted in such a way as to protect the anonymity of individual patients.

Chapter 4: Epidemiology of catastrophic rugby injuries

4.1. Introduction

Catastrophic rugby injuries are rare, however, when they occur, they may have debilitating consequences. The BokSmart guidelines define a catastrophic injury 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”(10). This definition includes traumatic, acute spinal cord injuries (ASCIs) and traumatic brain injuries (TBIs), and medical related events, such as major adverse cardiovascular events (MACE), that are life-threatening or result in permanent disability (97).

While catastrophic injuries are rare, it is imperative to report when they occur to ensure that preventative measures are being implemented and evaluate whether these are effective or not. Following a process of development between 2006 and 2010 (98), the BokSmart programme was widely implemented across South Africa by the end of 2011. One of the main purposes of the programme is to improve the surveillance, identification and management of injuries and provide education on injuries that occur while participating in rugby.

Given the rarity and unpredictable nature of these injuries, evaluating the effectiveness of prevention interventions using traditional experimental or prospective cohort studies is challenging. Continual, real-time injury surveillance and in-depth investigation of injury incidents is of value in detecting changes in injury epidemiology and outcomes and identifying areas for intervention improvements.

Between 2008 and 2014, the average annual incidence of disabling spinal cord injury in South African rugby was 1 per 100 000 participants, with a total of 87 catastrophic injuries during this period (16,94). A previous analysis of these catastrophic rugby injuries found no clear relationship between optimal management and outcome following ASCI (94). However, given the practice changes regarding the immediate management of ASCIs and TBIs in the intervening years, and the extra five-year data collection period since then, it is of value to analyse the CBPJPF/SARU catastrophic injury database with a specific focus on identifying changes in the epidemiology of catastrophic injuries in the period following widespread BokSmart implementation.

4.2. Objective

The objective of this part was to investigate the epidemiology of three catastrophic rugby injury categories (ASCI, TBI, MACE) in South Africa and analyse this for differences in the BokSmart pre- and post-implementation periods.

In order to meet this objective, the following will be addressed:

1. Describe the epidemiology, incident characteristics, and clinical outcomes of catastrophic rugby injuries in South Africa between 2008 and 2019.
2. Identify and compare the differences between the periods pre- and post-implementation of the BokSmart programme.

4.3. Methodology

As described in chapter three, all serious rugby injuries in South Africa are required to be reported to the BokSmart Serious Injury Case Manager (SICM) and are captured in the CBPJPF/SARU catastrophic injury database. This chapter includes an analysis of all injuries captured in the CBPJPF/SARU catastrophic injury database between 2008 and 2019.

4.4. Results

There were 147 catastrophic rugby injuries reported to the BokSmart SICM between 2008 and 2019. ASCIs accounted for 105 (71%) of these injuries, with TBIs and MACE accounting for a further 23 (16%) and 19 (13%) of all catastrophic injuries respectively (Table 4.1). There was a significant difference in the distribution of injuries by injury type before and after widespread implementation of the BokSmart programme (χ^2=7.702, p=0.021), with a reduced proportion of ASCIs and an increased proportion of MACE reported in the post-implementation period. When considering all catastrophic injuries, there was no significant difference in the mean number of injuries per year between the pre- (13.5 ± 2.9 injuries per year) and post-implementation (11.6 ± 1.5 injuries per year) periods (p=0.146). However, when excluding MACE due to the small sample size prior to 2011, there was a significant difference in the mean number of catastrophic injuries per year during the pre- (13.0 ± 2.2 injuries per year) and post-implementation (9.5 ± 0.9) periods (p=0.021). Similarly, there was a significant decrease in the mean number of ASCIs per year in the post-implementation period (pre-

implementation: 11.3 ± 2.5 injuries per year vs post-implementation: 7.5 ± 1.3 injuries per year; p=0.025). There was no significant difference in the mean number of TBIs per year between the pre- and post-implementation period (p=0.405).

Table 4.1 The distribution of catastrophic rugby injuries pre- and post-implementation of the BokSmart programme.

Injury Type	Pre-implementation (2008-2011)		Post-implementation (2012-2019)		All	
	n (%)	Mean number per year	n (%)	Mean number per year	n (%)	Mean number per year
Acute Spinal Cord Injury	45 (83)	11.3	60 (65)	7.5	105 (71)	9.0
Traumatic Brain Injury	7 (13)	1.8	16 (17)	2.0	23 (16)	1.9
Cardiovascular Events	2 (4)	0.5	17 (18)	2.1	19 (13)	1.6
Total	**54**	**13.5**	**93**	**11.6**	**147**	**12.5**

Figures 4.1 and 4.2 below show the temporal trend in catastrophic injury frequency pre- and post-implementation of BokSmart. For ASCIs, there was an increasing number of injuries per year during the pre-implementation period (β: 1.9; R^2= 0.9627) and a trend towards a decreasing number of injuries (β: -0.2; R^2= 0.1607) post-implementation of BokSmart. When analysing TBIs there was a decrease in the number of reported injuries per year during the pre-implementation period (β: -0.9; R^2= 0.4629) and a trend towards an increase in reported injuries per year (β: 0.2857; R^2= 0.2449) post implementation of the BokSmart programme. No clear temporal trend was identified for the small number of cardiovascular injuries during either the pre-implementation (R^2= 0.0667) or post-implementation (R^2= 0.014) periods, although the mean number of cardiovascular events per year increased during the post-implementation period.

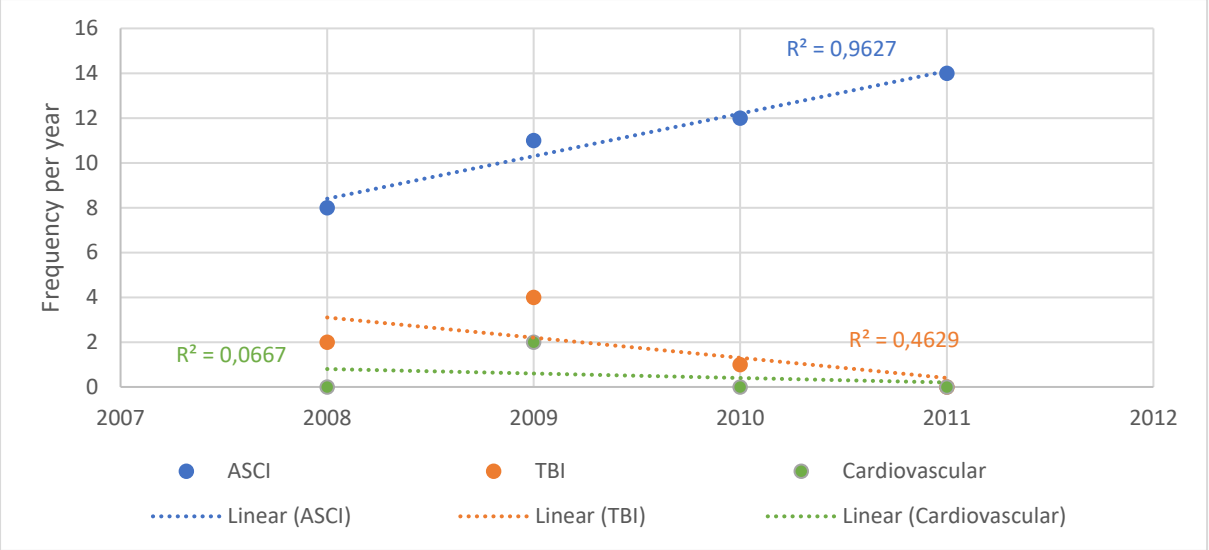

Figure 4.1 Line graph showing injuries per year pre-implementation of BokSmart

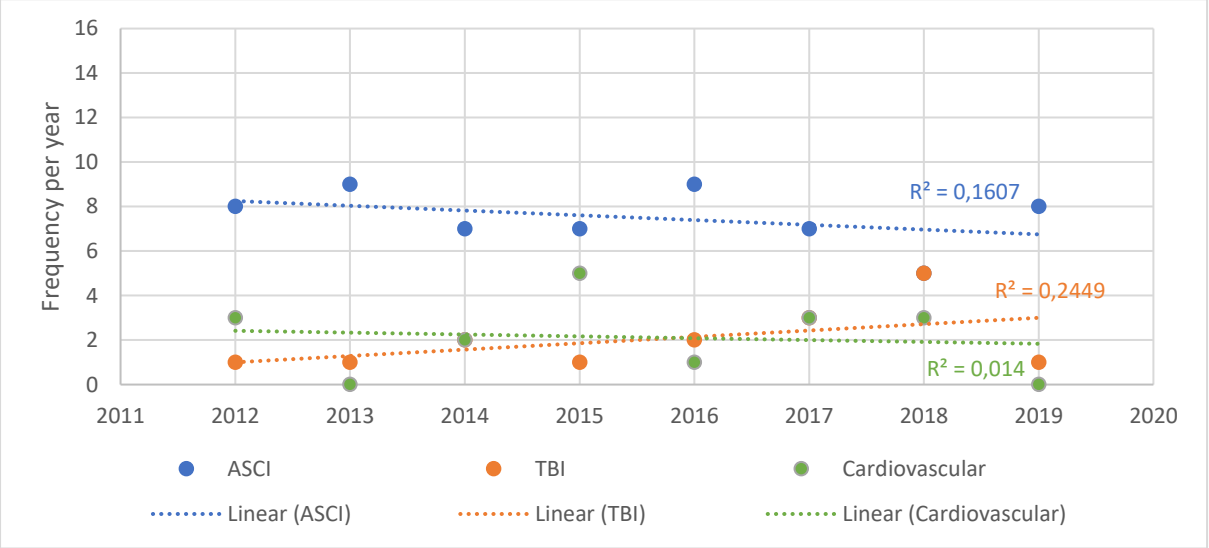

Figure 4.2 Line graph showing injuries per year post- implementation of BokSmart

During the study period, catastrophic injuries occurred at a variety of grades of play ranging from school level to international level professional rugby (Table 4.2). The majority of catastrophic injuries occurred at club grades of play with 84 (59%) catastrophic injuries; followed by school grades of play with 49 (34%) catastrophic injuries. Only eight (6%) catastrophic injuries occurred at professional grades of play (provincial and international). There was no significant difference in the distribution of the combined injuries by grade of play between the pre-implementation and post-implementation periods of the BokSmart

programme using a Fisher's exact test, (p= 0.116). Additionally, there was no significant difference in the distribution of either ASCIs (p=0.154) or TBIs (p=1.000) by grade of play between the pre-implementation and post-implementation periods using a Fisher's exact test. However, the average number of ASCIs per year at school grades of play was five injuries per year in the pre-implementation period of BokSmart, while the post-implementation period showed an average of two injuries per year. Although only a marginal decrease in the average number of ASCIs per year, from six to five injuries per year, was observed at the club grades of play. This shows a consistent reduction in the number of ASCIs per year at both school and club grades of play post the implementation of the BokSmart programme. There was a decrease in the average number of TBIs at school grades of play but an increase at club grades of play when comparing the average number of injuries per year pre- and post-implementation of the BokSmart programme. At school grades of play the mean number of TBIs was 1.00 and 0.88 per year pre- and post-implementation respectively. At club grades of play the mean number of TBIs was 0.75 and 1.00 injuries per year in the pre- and post-implementation periods respectively.

Table 4.2. The distribution of catastrophic rugby injuries by grade of play, pre- and post-implementation of the BokSmart programme.

Grade of play at time of injury	**All catastrophic injuries**			**Acute Spinal Cord Injury**			**Traumatic Brain Injury**			**Cardiovascular Event**		
	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
School	23 (46)	26 (28)	49 (34)	18 (40)	14 (23)	32 (30)	4 (57)	7 (44)	11 (48)	1 (50)	5 (29)	6 (32)
Club	25 (50)	59 (63)	84 (59)	25 (56)	40 (66)	65 (62)	3 (43)	8 (50)	11 (48)	1 (50)	11 (65)	12 (63)
Provincial	1 (2)	6 (7)	7 (5)	1 (2)	4 (7)	5 (5)	Nil	1 (6)	1 (4)	Nil	1 (6)	1 (5)
International	Nil	1 (1)	1 (1)	Nil	1 (2)	1 (1)	Nil	Nil	Nil	Nil	Nil	Nil
Unknown	1 (2)	1 (1)	2 (1)	1 (2)	1 (2)	2 (2)	Nil	Nil	Nil	Nil	Nil	Nil
Total	**50**	**93**	**143**	**45**	**60**	**105**	**7**	**16**	**23**	**2**	**17**	**19**

On analysis of a player's positional grouping at the time of injury, it was found that 90 (63%) catastrophic injuries occurred while a player was playing in a forward position, while 39 (27%) catastrophic injuries occurred in the backline positions (Table 4.3). There was a significant difference in the distribution by positional grouping when comparing the incidence of ASCIs and TBIs, with ASCIs occurring more frequently in forward players and TBI occurring more frequently in backline players (OR= 4.235; 95% CI: 1.569-11.432; χ^2=8.541, p=0.003). There was no significant difference in the distribution of ASCIs in the pre- and post-implementation periods when comparing forward and backline players (p=0.110). When comparing TBIs by positional grouping (forwards compared to backline players) in the pre- and post-implementation periods, there was no significant difference seen (p=0.603). When considering all catastrophic injuries, forwards were 2.8 (95% CI: 1.2-6.5) times as likely to be injured during the pre-implementation period rather than the post-implementation period compared to backline players. During the study period, ASCIs were most commonly sustained by hookers (25 (24%)), loose forwards (22 (21%)), and prop forwards (17 (16%)). Collectively, 54 (52%) of the ASCIs occurred to players in the tight five positions. TBIs occurred most frequently in the loose-forwards, 5 (25%), and wings, 5 (25%).

The majority of catastrophic injuries occurred during matches, a total of 124 (86%) catastrophic injuries (Table 4.4). There was no significant difference in the distribution of injuries by activity between the pre- and post-implementation periods (p=0.911). There was a total of 102 ASCIs of which 95 (93%) occurred during match play. Similarly of the 23 TBIs that were recorded, 21 (91%) occurred during match play. The majority MACE (8 (42%)) occurred during match play, but it is interesting to note that approximately a quarter (5 (26%)) occurred in the 24-hour period following either a match or training session.

Catastrophic injuries most frequently occurred during the tackle (71 (55%)), followed by the scrum (28 (22%)), and ruck (19 (15%)) phases (Table 4.4). An analysis of the distribution of injury by phase of play during which the injury occurred showed a significant difference between the pre-implementation period and post-implementation period for all injuries (p=0.008). Specifically, the odds of a catastrophic injury occurring during the tackle compared to all other phases of play were lower in the pre-implementation period (22 (42%)) than in the post-implementation period (49 (40%); OR=0.403; 95% CI: 0.195-0.830; χ^2=6.080; p=0.014).

Conversely, the odds of a catastrophic injury occurring during the scrum compared to all other phases of play were higher in the pre-implementation period (19 (36%)) than in the post-implementation period (9 (12%); OR=4.222; 95% CI: 1.747-10.207; χ^2=10.671; p=0.001). This effect was largely due to changes in the distribution of ASCI by phase of play. The odds of ASCIs occurring during the tackle compared to all other phases of play were lower in the pre-implementation period (17 (40%)) than in the post-implementation period (37 (63%); OR=0.357; 95% CI: 0.0161-0.795; χ^2=6.356; p=0.012). The odds of an ASCI occurring during the scrum compared to all other phases of play were higher in the pre-implementation period (19 (44%)) than in the post-implementation period (9 (15%); OR=4.138; 95% CI: 1.664-10.288; χ^2=9.615; p=0.002).

When analysing anatomical injury sites in ASCIs during the pre- and post-implementation periods (Table 4.5), the cervical spine showed the highest proportion of injury for both periods. In the pre-implementation period, there were 42 (94%) reported cases and 54 (91%) reported cases in the post-implementation period. When comparing residual morbidity outcomes with near-miss outcomes, there was also no significant difference in the outcome classification of ASCIs between the pre-implementation and post-implementation periods (χ^2=2.354; p=0.125). Injured players with residual morbidity following an ASCI were 1.8 times as likely to have been injured during the pre-implementation period, compared to players who suffered a near-miss ASCI. Figure 4.3. shows the distribution of outcome at one month following an ASCI using the ASIA grading scale. There was no significant difference in the ASIA grading scale within one month of injury between the two periods (χ^2=5.158; p=0.076).

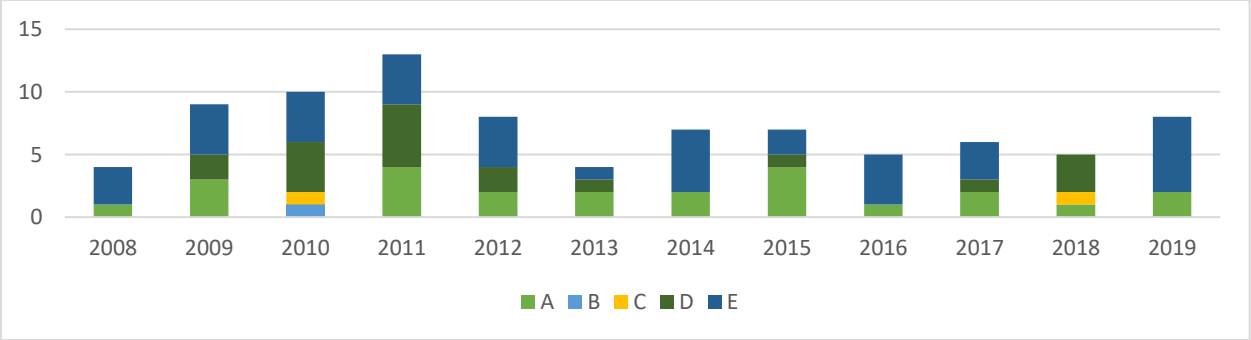

Figure 4.3 Acute spinal cord injuries (ASCI) Acute Spinal Cord Injury Association (ASIA) outcome by year

-A: Complete impairment; B-D: Incomplete impairment; E: Normal

When analysing the outcomes of TBIs, there was no significant difference in the distribution of the near-misses between the pre- and post-implementation periods of BokSmart (pre-implementation: 2 (29%) versus post-implementation: 3 (19%)) and fatalities or injuries with disability (pre-implementation: 5 (71%) versus post-implementation: 13 (81%); p= 0.621; Table 4.6). In particular, fatal TBIs and those resulting in residual loss of function were 0.6 times less likely to occur in the pre-implementation period compared to near-miss TBIs with full-recovery.

Table 4.3 The distribution of catastrophic rugby injuries by positional grouping, pre- and post-implementation of the BokSmart programme

Position	**Combined Injuries**			**Acute Spinal Cord Injury**			**Traumatic Brain Injury**			**Cardiovascular Event**		
	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Forwards	**41 (80)**	**49 (54)**	**90(63)**	**36 (80)**	**41 (69)**	**77 (74)**	**3 (60)**	**5 (33)**	**8 (40)**	**2 (100)**	**3 (18)**	**5 (26)**
Prop	6 (12)	12 (13)	18 (13)	5 (12)	12 (20)	17(16)	Nil	Nil	Nil	1 (50)	Nil	1 (5)
Hooker	15 (29)	13 (14)	28 (20)	15 (35)	10 (17)	25 (24)	Nil	1 (7)	1 (5)	Nil	2 (12)	2 (11)
Lock	5 (10)	9 (10)	14 (10)	4 (9)	8 (14)	12 (12)	1 (20)	1 (7)	2 (10)	Nil	Nil	Nil
Loose forward	14 (27)	15 (16)	29 (20)	11 (26)	11 (19)	22 (21)	2 (40)	3 (20)	5 (25)	1 (50)	1 (6)	2 (11)
Sevens forward	1 (2)	Nil	1 (1)	1 (2)	Nil	1 (1)	Nil	Nil	Nil	Nil	Nil	Nil
Backline	**9 (18)**	**30(33)**	**39 (27)**	**7 (16)**	**18 (31)**	**25 (24)**	**2 (40)**	**9(60)**	**11 (55)**	**Nil**	**3 (18)**	**3 (16)**
Scrumhalf	1 (2)	8 (9)	9 (6)	1 (2)	4 (7)	5 (5)	Nil	1 (7)	1 (5)	Nil	3 (18)	3 (16)
Flyhalf	4 (8)	3 (9)	7 (5)	2 (5)	3 (5)	5 (5)	2 (40)	Nil	2 (10)	Nil	Nil	Nil
Wing	1 (2)	8 (9)	9 (6)	1 (2)	3 (5)	4 (4)	Nil	5 (33)	5 (25)	Nil	Nil	Nil
Centre	1 (2)	7 (8)	8 (6)	1 (2)	5 (8)	6 (6)	Nil	2 (13)	2 (10)	Nil	Nil	Nil
Fullback	1 (2)	4 (4)	5 (3)	1 (2)	3 (5)	4 (4)	Nil	1 (7)	1 (5)	Nil	Nil	Nil
Sevens backline	1 (2)	Nil	1 (1)	1 (2)	Nil	1 (1)	Nil	Nil	Nil	Nil	Nil	Nil
Unspecified	2 (4)	12 (13)	14 (10)	2 (5)	Nil	2 (2)	Nil	1 (7)	1 (5)	Nil	11 (65)	11 (58)
Total	**51**	**91**	**143**	**45**	**59**	**104**	**5**	**15**	**20**	**2**	**17**	**19**

Table 4.4 The distribution of catastrophic rugby injuries by activity and phase of play, pre- and post-implementation of the BokSmart programme

Activity	All catastrophic Injuries			Acute Spinal Cord Injury			Traumatic Brain Injury			Cardiovascular Event		
	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total	2008-2011	2012-2019	Total
	n (%)	**n (%)**	**n (%)**	**n %**	**n %**	**n (%)**	**n %**	**n %**	**n (%)**	**n %**	**n %**	**n (%)**
Match	45 (87)	79 (86)	124 (86)	38 (88)	57 (97)	95 (93)	6 (86)	15 (94)	21(91)	1 (50)	7 (41)	8 (42)
Training	7(13)	8 (9)	15 (10)	5 (12)	2 (3)	7 (7)	1 (14)	1 (6)	2 (8)	1 (50)	5 (29)	6 (32)
Within 24 hours of match/ training	Nil	5 (5)	5 (3)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	5 (29)	5 (26)
Total	**52**	**92**	**144**	**43**	**59**	**102**	**7**	**16**	**23**	**2**	**17**	**19**
Phase of play												
Collision	1 (2)	3 (4)	4 (3)	1 (2)	1 (2)	2 (2)	Nil	2 (13)	2 (9)	Nil	Nil	Nil
Lineout	1 (2)	Nil	1 (1)	Nil	Nil	Nil	1 (14)	Nil	1 (5)	Nil	Nil	Nil
Maul	1 (2)	Nil	1 (1)	Nil	Nil	Nil	1 (14)	Nil	1 (5)	Nil	Nil	Nil
Ruck	7 (13)	12 (16)	19 (15)	7 (16)	11 (19)	18 (17)	Nil	1 (6)	1 (5)	Nil	Nil	Nil
Scrum	19 (36)	9 (12)	28 (22)	19 (44)	9 (15)	28 (27)	Nil	Nil	Nil	Nil	Nil	Nil
Tackle	22 (42)	49 (65)	71 (55)	17 (40)	37 (63)	54 (52)	4 (57)	12 (75)	16 (73)	1 (50)	Nil	1 (50)
Unclear	2 (4)	2 (3)	4 (3)	1 (2)	1 (2)	2 (2)	Nil	1 (6)	1 (5)	1 (50)	Nil	1 (50)
Total	**53**	**75**	**128**	**45**	**59**	**104**	**6**	**16**	**22**	**2**	**0**	**2**

Table 4.5 The distribution of acute spinal cord injuries and outcomes, pre- and post-implementation of the BokSmart programme

Site of injury	Acute Spinal Cord Injury		
	2008-2011	2012-2019	Total
	n %	n %	n (%)
Head	1 (2)	Nil	1 (1)
Cervical Spine	42 (94)	54 (91)	96 (92)
Thoracic Spine	Nil	5 (8)	5 (5)
Lumbar Spine	2 (4)	Nil	2 (2)
Total	**45**	**59**	**104**
Outcome classification			
Residual morbidity	27 (63)	28 (48)	55 (54)
Near-miss	16 (37)	31 (52)	47 (46)
Total	**43**	**59**	**102**
Outcome of injury: ASIA SCALE within 1 month after injury			
A-D – Complete and incomplete	20 (57)	19 (38)	39 (46)
E – Normal	15 (43)	31 (62)	46 (54)
Total	**35**	**50**	**85**

Table 4.6 The distribution of traumatic brain injuries and outcomes, pre- and post-implementation of the BokSmart programme

Outcome classification	**Traumatic Brain Injury**		
	2008-2011	**2012-2019**	**Total**
	n %	**n %**	**n (%)**
Fatal	4 (57)	8 (50)	12 (52)
Residual (with disability)	1 (14)	5 (31)	6 (26)
Near-miss (Full recovery)	2 (29)	3 (19)	5 (22)
Total	**7**	**16**	**23**

4.5. Discussion

The BokSmart programme was developed as an injury prevention programme by implementing injury prevention training and educating coaches and referees in improving injury surveillance, identification and reporting (48,49). It included various changes in 2011 to make the game of Rugby safer for participants and to provide guidelines to stakeholders in the event of a serious injury. Some of the changes included making the attendance of the BokSmart course compulsory for coaches and referees regardless of the grade of play, changes in the scrum laws and the introduction of a blue card for concussions (16,34,73). These changes are similar to the New Zealand RugbySmart programme which was implemented in 2000 (99) and the Australian Rugby Smart programme (100).

This analysis sought to describe the epidemiology and clinical outcomes of catastrophic rugby injuries in South Africa between 2008 and 2019 and to compare this before and after the implementation of the BokSmart programme. The findings of this analysis suggests that the implementation of the programme is associated with changes in the epidemiology of catastrophic injuries between the pre- and post-implementation periods. Most notably, there was a significant decrease in the mean number of catastrophic injuries (including ASCIs and TBIs) per year following the implementation of the BokSmart programme. This effect is predominantly due to a significant decrease in the mean number of ASCIs per year following the implementation of the BokSmart programme. This finding is similar to a study by Quarrie *et al.* (2007), who found that there was a decrease in ASCIs post the implementation of the New Zealand RugbySmart programme (99). Furthermore, incidents in which players suffered ASCIs with poor outcomes at one month were more likely to occur in the pre-implementation compared to those ASCIs with favourable outcomes. This could be due to better injury prevention techniques, improved injury recognition; better player training techniques and strategic law changes implemented by BokSmart (48).

Although the number of TBIs was relatively small; there was a 7.1% decrease in fatal outcomes post the implementation of BokSmart. However, there was an increase in TBIs with residual disability and a decrease in near-miss injuries with full recovery. Improvements in injury recognition and management could account for less fatalities as a result of head injuries, and a shift from fatal outcomes towards non-fatal outcomes. These include concussion recognition programmes that have been implemented by BokSmart (50). World Rugby has a

guideline on concussion management which were adopted by SARU in 2015 (101). In 2019, BokSmart implemented the blue card system which allows referees to issue a blue card if a player presents with concussion symptoms. It will act as a signal to all watching that a player may be concussed and improves injury surveillance and reporting. The aim is to reduce the negative outcomes of concussions and protect players (73).

There were also a very small number of MACE reported. Pre-implementation of BokSmart a total of two fatal MACE were reported, yet in the period post the implementation of the BokSmart programme 15 fatal events and two non-fatal events were reported. The implementation of clear guidelines as to what to report and when to report with the follow-up from the Serious Injury Case Manager (SICM) could be attributed to the better reporting seen in the post-implementation period. This can be seen by the fact that five MACE were reported in the 24 hours post a match or training session, while there were no MACE reported in the pre-implementation period. Internationally there has been greater awareness of sudden cardiac arrest in athletes and specific education programmes and improved screening of players (63). It is likely that the increased number of TBIs and MACE in the post-implementation period is due to the improvement of injury identification and reporting post the implementation of the BokSmart programme (49).

4.5.1. Injury characteristics

Although there was no significant difference in the distribution of injuries between the school and adult grades of play there was a decrease in the mean number of injuries per year for all injury types at the school grades of play in the post-implementation period. Within the adult grades of play, most injuries occurred at club grades of play. This likely reflects the larger rugby playing population at the level but could also be attributed to a variety of reasons including less implementation of injury prevention techniques, less stringent law enforcements, insufficient training and playing in unfamiliar positions (43). One study, by Swain *et al.* (2016), found that amateur players sustained more injuries than professional players although they were less severe than the injuries sustained by professional players (102). There have been several articles that state that professional level players experience more injuries of all types and severities than lower levels of play (103,104), however from the data analysis it would appear that professional level players experience fewer catastrophic injuries than lower grades of play. There were no cardiovascular events at any of the professional grades of play,

this could possibly be due to better pre-screening of players before participating in rugby due to the availability of higher levels of medical support. Although there was no significant difference in the distribution of injuries between matches and training, 87% of all catastrophic injuries occurred during matches as opposed to training periods.

There was a significant difference in the distribution by positional grouping at the time of injury, with more injuries in the forward players overall. However, there was a sharp increase in the proportion of injuries in backline players post-implementation of the BokSmart programme. This finding that forward players experienced more injuries than backline players is similar to other studies, and it is seen that forward players are exposed to more frequent collisions with higher forces than backline players (105). Prior to the implementation of the Rugby Smart programme in Australia, Taylor *et al.* (2003) found that forwards were twice as likely to sustain spinal cord injuries as compared to backline players (106). In a narrative synthesis by Hendricks *et al.* (2021), it was found that forward players perform more tackles than backline players and thus are at a higher risk for injury (103).

There was a significant difference in the distribution of the event that caused the injury pre- and post-implementation of the BokSmart programme (p= 0.006). The biggest changes were seen in the tackling and scrumming events. Scrumming showed the most significant decrease in the proportion of catastrophic injuries. In 2012, the scrum laws were changed after catastrophic injury data were collected and analysed from the period prior to the implementation of BokSmart. In the period prior to the implementation of BokSmart of all the ASCIs, 13 (68%) of these were permanent injuries (34). The major changes in the scrum laws included a shorter distance between teams for binding in the scrum and a change in the calls used for scrumming to allow the referee to better control the scrum sequence (34). The aim of these law changes was to “minimise the opportunity for impact injury and subsequent scrum collapse” (34). These law changes have clearly made an impact on the occurrence of all catastrophic injuries as a result of the scrum. This was a finding similar to the New Zealand RugbySmart programme, where they found a decrease in injuries post changes to scrum laws (99).

Recently, Hendricks *et al.* (2021) found that there has been a shift in focus to safety when tackling in both amateur and professional levels of play. It was found that tackle injuries occurred at a higher frequency at professional and semi-professional grades of play than at

amateur grades of play (103). A study, by Burger *et al.* (2014) focussing on tackle-related injuries in South African Youth Rugby Union players found that most tackle-related injuries occurred near the end of a match with incorrect tackling technique being a major contributor (107). There has been a recent shift in focus (2019) to improve technical training at various grades of play with a focus on tackle and ruck proficiency (108) as well as implementation of recovery strategies to improve conditioning of players (107).

4.5.2. Acute spinal cord injuries

Although there was no significant difference found in the anatomical location or outcomes of ASCIs, there were some notable changes between the pre- and post-implementation periods. In terms of the outcome classification, there was a higher proportion of near-miss injuries in the post-implementation period as compared with the pre-implementation period. This is similar to changes observed with the RugbySmart programme, where there was a sharp decrease in the number of ASCIs with permanent outcomes post the implementation of their programme in 2000 (99).

Although there was a slightly higher percentage of complete muscle and sensory impairment (ASIA Scale category A) in the post-implementation there was also a larger proportion of normal outcomes (ASIA Scale category E) evident in the post-implementation period. This could imply that the BokSmart programme has improved injury prevention and recognition following its implementation and resulted in a subtle shift towards less severe outcomes following an ASCI.

4.5.3. Summary

In this chapter, we set out to investigate the epidemiology of all catastrophic rugby injuries in South Africa. Overall, it can be inferred that, following the implementation of the BokSmart programme, there has been a decrease in the frequency of catastrophic rugby injuries, specifically ASCIs.

While there may have been an improvement in the recognition and reporting of catastrophic injuries, more research may be needed into specific areas to improve the injury surveillance, prevention and management of catastrophic injuries when they occur.

Limitations of this study would include the small sample size due to the rarity of catastrophic injuries, as well as several cases in the CBPJPF/SARU catastrophic injury database that were incomplete or had missing data points.

Post the implementation of the BokSmart programme there was a decrease in the annual frequency of catastrophic injuries overall. However, club level matches still reported a higher proportion of catastrophic injuries. Scrumming laws were changed in 2012, and this saw a decrease in the proportion of catastrophic injuries. ASCIs accounted for the highest proportion of all catastrophic injuries, with a higher proportion of normal outcomes as compared to the pre-implementation period.

Chapter 5: Field-side management of catastrophic rugby injuries

5.1. Introduction

The field-side management of catastrophic injuries may have an impact on the outcome of the injury and the experience of the injured player (23). There is also a substantial risk to catastrophically injured players if their condition is managed inappropriately as the risk of deterioration is increased (109). When a potentially catastrophic injury occurs, a key consideration in the medical management of the player is to minimise the risk of secondary injury following the primary injury (110) and where possible, improve the injured player's condition.

The *Safety in the playing environment* document is one of many guidelines set out by BokSmart (52). This document specifies various aspects of training and matches to ensure that rugby can be played safely, and which procedures should be followed in the event of an emergency. Additionally, BokSmart has released *A practical guide to playing smart rugby* (85), which provides details on the clinical management of specific injuries on the field side. The guideline pays close attention to catastrophic injuries and their management.

These two guidelines, *Safety in the playing environment* and *A practical guide to playing smart rugby*, specify the type of personnel that should be present to render medical care at the field-side, the equipment that should be available for use in the event of a catastrophic injury, how and when the injured player should be transported to hospital. It is of value to ascertain whether these guidelines are being adhered to in the management of injured players following the implementation of the BokSmart programme, because there is evidence from other programmes that the guidelines show a decrease in the occurrence of catastrophic injury (111). Given the small number of traumatic brain injuries (TBIs) and major adverse cardiovascular events (MACE) reported in the dataset, most specifically in the pre-implementation period (Table 4.1), this chapter will focus on the clinical management of players who have suffered catastrophic injuries, and then specifically on acute spinal cord injuries (ASCI) and its association with their clinical outcomes.

5.2. Objective

The objective of this part was to describe and analyse immediate post-injury management and its association with player outcomes following catastrophic rugby injuries in South African rugby between 2008 and 2019.

In order to meet this objective, the following will be addressed:

1. To describe and compare immediate post-injury management in relation to the *Safety in the Playing Environment* Document and *A practical guide to playing smart rugby* in the pre- and post-implementation period.
2. To compare player outcomes following ASCIs between incidents with a high optimal management score and incidents with deficits in post-injury management

5.3. Methodology

As described in chapter three, all serious rugby injuries in South Africa are required to be reported to the BokSmart Serious Injury Case Manager and are captured in the CBPJPF/SARU catastrophic injury database. This chapter includes a descriptive analysis of the immediate post-injury management of all serious rugby injuries.

5.4. Results

The results are presented in accordance with the focus areas for immediate post-injury management described in detail in the *Safety in the playing environment* document (table 5.1) (52) and split into various topics. These include the first on-field medical support; where the injured player was first attended; what equipment was utilised to spinal motion restrict the injured player; whether oxygen was administered; whether Spineline was contacted; how long it took to transport the injured player to hospital and what mode of transport they were transported in.

5.4.1. On-field medical support and attendance

In 85 (87%) ASCI cases, players received on-field medical support by either a lay rescuer (43 (44%)) or a registered medical care professional (42 (43%)) with only 12 (12%) players receiving no on-field medical support (Table 5.1). There was no significant difference between the pre- and post-implementation periods in the distribution of the type of on-field medical support (χ^2=2.109, p=0.146). Although this distribution was not significantly different

between the two periods, there was a 15% increase in the post-implementation period in the proportion of incidents in which the first on-field medical support was a registered medical care professional. Incidents in which the first on-field medical support was a registered medical care professional were 2.0 (95% CI: 0.9 – 4.6) times as likely to occur in the post-implementation period compared to those in which lay rescuers were first on-field or in which there was no on-field medical support (Pre-implementation: 14 (34%) versus post-implementation: 28 (50%)). Interestingly, there was a 15% increase in the proportion of cases in which a registered emergency medical services (EMS) professional was the first on-field medical support in the post-implementation period. With regards to where medical care was initiated, there was a small increase (7%) in the proportion of cases in which injury management was initiated on the field as opposed to off the field, but this was not significant (χ^2=1.247, p=0.264).

In 13 complete TBI cases, only one (7%) case received on-field support by a registered medical care professional in the pre-implementation period, while four (31%) players were given on-field medical care by registered medical care professionals and 3 (23%) players were given on-field medical support by lay rescuers in the post-implementation period.

While there were only two (11%) pre-implementation period MACE cases, there was no information provided about the first on-field medical support recorded in the database. In the post-implementation period, in one (5%) case the first on-field medical support was a lay rescuer, and four (21%) players were given on-field medical support by registered medical care professionals.

5.4.2. Spinal motion restriction of injured players with ASCIs and TBIs

Spinal motion restriction (SMR) should comprise of at least a firm board, spider harness and head blocks (52). When comparing the pre- (21 (51%)) and post-implementation (38 (68%)) periods there was no significant difference in the proportion of incidents in which full SMR was applied (χ^2=2.750, p=0.097). There was no difference between the two periods in the proportion of incidents, for players who suffered an ASCI, in which a neck brace or cervical collar was used, and only a small increase (16 (7%)) in the proportion of incidents in which head blocks were used. Similarly, there was a 10% increase in the proportion of incidents in which the patient was secured with a spider harness in the post-implementation period, 39 (70%), compared to the pre-implementation period, 22 (60%). Specifically, patients were 1.6

times (95% CI: 0.7-3.7) more likely to be stabilised with a spider harness in the post-implementation period.

In ASCIs in the pre-implementation period, there were 28 (65%) cases of the total number of cases that indicated spinal board usage with an equal amount indicating head block utilisation, but only 22 (79%) of those cases indicated spider harness usage. In the post- implementation period, 47 (84%) of the total cases indicated spine board usage, of those 44 (94%) indicated head block usage and only 39 (83%) of the 47 cases indicated spider harness utilisation.

In TBI cases there were two (15%) cases in which there was application of a cervical collar in the post-implementation period. In the post-implementation period, two (15%) cases were found to apply full SMR while 7 (54%) cases were found to have applied incomplete SMR.

5.4.3. Transportation of the injured player

In the *Safety in the playing environment* document, it is recommended that Spineline should be contacted in the event of a catastrophic injury and oxygen should be considered. Interestingly, in the pre-implementation period, oxygen was administered more frequently (3 (20%)), and Spineline was contacted more frequently (14 (36%)) compared to the post-implementation period (6 (12%) and 12 (25%) respectively) in ASCI cases. For TBIs, only one (5%) case utilised oxygen in the post-implementation period. Spineline was contacted in two (11%) MACE cases and two (15%) TBI cases in the post- implementation period.

When analysing ASCIs for both the pre- (37 (93%)) and post-implementation (48 (87%)) periods, the large majority of injured players were transported to hospital in less than four hours as per recommendations (Table 5.1). There was no significant difference in the proportion of cases being transported to hospital in under four hours between the two periods (χ^2=0.346, p=0.556). Similarly, the majority of patients (77 (79 %)) were transported to definitive care by ambulance; however, there was no significant difference in the mode of transport to hospital between the two periods (χ^2=0.734, p=0.392).

There was an increase in the proportion of TBI cases being transported to definitive care in less than one hour in the post-implementation period (5 (38%)) as compared to the pre-implementation period (1 (8%)). There was an equal proportion of cases in the post-implementation period that were transported by ambulance (4 (31%)) and by private vehicle (4 (31%)).

Seven (37%) cases of MACE in the post-implementation period and both cases in the pre-implementation period were transported by ambulance to definitive care. Only one (5%) case was transported by private vehicle in the post-implementation period.

5.4.4. MACE and immediate medical care

Of the 19 cases of MACE, only five (26%) cases in the post-implementation recorded resuscitation efforts at the field side. There were two (11%) cases in the pre-implementation period with no indication of whether resuscitation was carried out or not.

5.4.5. Optimal Management Score in ASCIs

When analysing only cases with two or less missing data points (n=95), the median Optimal Management Score for all ASCIs during the study period was seven (Table 5.1) and only 38% of cases achieved a score of eight or higher (Figure 5.1). Although there was in increase in the proportion of cases achieving an Optimal Management Score of eight or higher in the post-implementation period (25 (46%)) compared to the pre-implementation period (11 (28%)) this difference was not significant (χ^2=3.172, p=0.075). However, achieving an Optimal Management Score of eight or higher in the post-implementation period was 2.2 times (95% CI: 0.9-5.3) more likely than a score of less than eight.

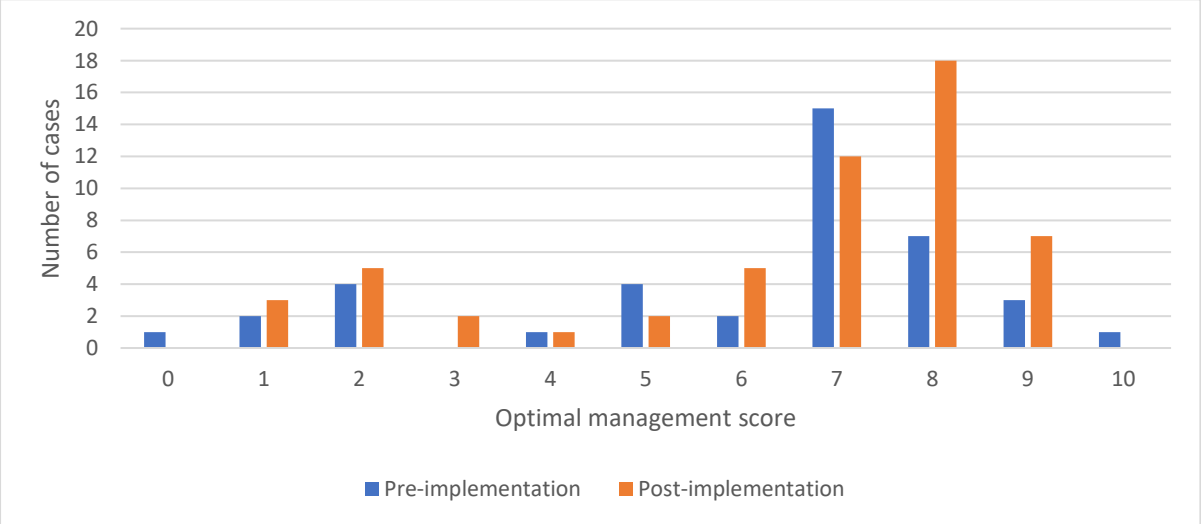

Figure 5.1 The distribution of optimal management score (/10) for catastrophic injuries (n=95) in the pre- and post-implementation periods

Table 5.1 Immediate post-injury management of catastrophic rugby injuries in South Africa between 2008 and 2019

	Pre-implementation (2008-2011) n(%)	**Post-implementation (2012-2019) n(%)**	**All n(%)**
First on-field medical support			
Registered medical care professionals	**14 (34)**	**28 (50)**	**42 (43)**
Medical doctor	1 (2)	3 (5)	4 (4)
EMS	10 (24)	22 (39)	32 (33)
Physiotherapist	1 (2)	3 (5)	4(4)
Biokinetiscist	1 (2)	Nil	1 (1)
Nurse	1 (2)	Nil	1(1)
Lay rescuers	**21 (51)**	**22 (39)**	**43 (44)**
Rugby Medic	5 (12)	Nil	5 (5)
First aider	16 (39)	22 (39)	38 (39)
None	**6 (15)**	**6 (11)**	**12 (13)**
Total	**41**	**56**	**97**
When first attended			
On-field	35 (81)	50 (89)	85 (86)
Off-field	8 (19)	6 (11)	14 (14)
Total	**43**	**56**	**99**
Neck brace/collar used	31 (78)	42 (76)	73 (77)
Neck brace/ collar not used	9 (22)	13 (24)	22 (23)
Total	**40**	**55**	**95**
Placed on stretcher or spinal board	32 (80)	46 (82)	78 (81)
Not placed on stretcher or spine board	8(20)	10 (18)	18 (19)
Total	**40**	**56**	**96**
Stabilised with spider harness	22 (60)	39 (70)	61 (66)
Not stabilised with spider harness	15 (40)	17 (30)	32 (33)
Total	**37**	**56**	**93**
Head blocks used	28 (72)	44 (79)	72 (76)

No head blocks used	11 (28)	12 (21)	23 (24)
Total	**39**	**56**	**95**
Oxygen given	3 (20)	6 (12)	9 (14)
No oxygen given	12 (80)	45 (88)	57 (86)
Total	**15**	**51**	**66**
Spineline called	14 (36)	12 (25)	26 (30)
Spineline not called	25 (64)	36 (75)	61 (70)
Total	**39**	**48**	**87**
Time to hospital			
Total <4 hours	40 (89)	51 (88)	91 (88)
<1 hour	32 (71)	39 (67)	71 (69)
1-2 hours	6 (13)	8 (14)	14 (14)
2-3 hours	1 (2)	1 (2)	2 (2)
3-4 hours	1 (2)	3 (5)	4 (4)
>4 hours	5 (11)	7 (12)	12 (12)
Total	**45**	**58**	**103**
Mode of transport to hospital			
Ambulance	32 (78)	45 (80)	77 (79)
Private vehicle	9 (22)	8 (14)	17 (18)
Other	Nil	3 (6)	3(1)
Total	**41**	**56**	**97**
Optimal management score (/10)*			
Median	7	7	7
Interquartile range	3-7	5-8	5-8
Cases ≥8	11 (28)	25 (46)	36 (38)
Total	**40**	**55**	**95**

* Includes only cases with two or less missing data points (n=95).

5.4.6. On-field medical support and attendance

There was no significant difference in the distribution of the type of first on-field medical support when categorised by outcome (χ^2=0.011, p=0.915). In the 42 (44%) ASCI cases with a permanent outcome, there was an equal proportion of registered medical care professionals (21 (38%)) and lay rescuers (21 (38%)) providing the first on-field medical support. Similarly,

there was no significant difference in the distribution of patients either attended on or off the field (p=1.000) between ASCIs with a permanent outcome compared to those with a more favourable outcome (Table 5.2).

5.4.7. Spinal motion restriction of injured players

With regards to SMR being applied, cervical collars were utilised in a higher proportion of cases with permanent outcomes (44 (88%)) as compared to non-permanent outcomes (29 (64%)). In the permanent outcomes category, full SMR equipment was utilised in a higher proportion (34 (68%)) than in the non-permanent outcomes category, (25 (54%)). However, there was no significant difference found (χ^2=1.885, p=0.170). Similarly, oxygen was also utilised more frequently in the permanent outcomes category (6 (19%)) as compared to the non-permanent outcomes category (3 (9%)) although this utilisation was low in both categories. Spineline was also called more frequently in the permanent outcomes category (17 (35%)).

5.4.8. Transportation of the injured player

There was no significant difference in the time it took before the injured player was transported to hospital (p=0.1339). There was a significant difference in the distribution of the mode of transport used to transport the injured player to hospital between outcome categories (p=0.031) with a higher proportion of patients with permanent outcomes being transported by ambulance (46 (90%)). In both permanent and non-permanent outcomes an ambulance (77 (82%)) was utilised to transport patients to definitive care in a higher proportion of cases than private vehicles (17 (18%)).

5.4.9. Optimal Management Score

When analysing cases with two or less missing data points (n=103), the median Optimal Management Score for all ASCIs with both permanent and non-permanent outcomes was seven (Table 5.2). On analysis of the Optimal Management Score between the outcome categories, there was no significant difference (χ^2=2.022, p=0.155). Interestingly, a permanent outcome (23 (46%)) following an ASCI was 1.8 times (95% CI: 0.8-4.2) as likely to occur when the Optimal Management Score was eight or above compared to ASCIs with a non-permanent outcome (13 (28%)).

ASCI outcome at one month was categorised by the ASIA grading scale (Any kind of deficit (A-D) versus no deficit (E)), and there was no significant difference in the distribution of these outcomes found between the optimal management and sub-optimal management cases (χ^2=2.028, p=0.154) (Figure 5.2).

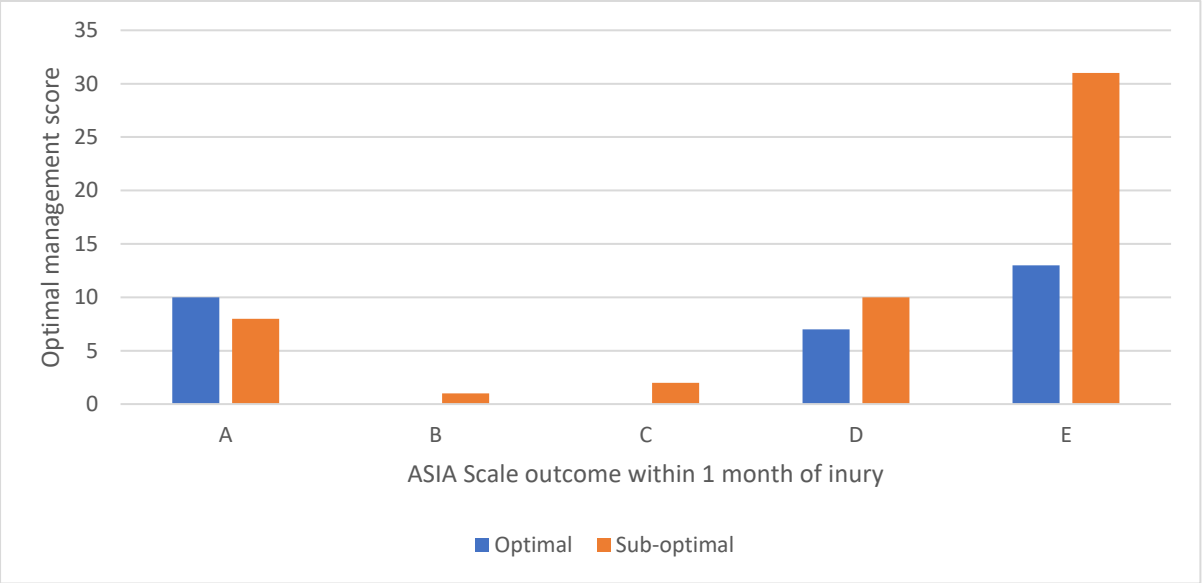

Figure 5.2 The distribution of the Acute Spinal Cord Injury Association (ASIA) Scale outcome within one month of acute spinal cord injury (ASCI) by optimal management score, excluding fatal outcomes.

Table 5.2 The distribution of elements of immediate post-injury management by ASCI outcome

	Permanent outcome n (%)	**Non-permanent outcome n (%)**	**All n (%)**
First on-field medical support			
Registered medical care professionals	21 (38)	21 (45)	42 (44)
Lay rescuer	21 (38)	22 (47)	43 (45)
None	9 (16)	2 (4)	11 (11)
Total	**51**	**45**	**96**
When first attended			
On field	32 (88)	30 (88)	62 (86)
Off field	4 (11)	4 (12)	8 (11)
Total	**36**	**34**	**70**
Spinal motion restriction applied			
Neck brace/collar used	44 (88)	29 (64)	73 (77)
Placed on stretcher or spinal board	45(90)	33(72)	78 (81)
Stabilised with spider harness	35(74)	26(57)	61 (66)
Head blocks used	42(86)	30(65)	72 (76)
Oxygen given	6(19)	3(9)	9 (14)
Spineline called	17(35)	9(23)	26 (30)
Time to hospital			
Total <4 hours	48 (87)	43 (93)	91 (90)
<1 hour	37 (67)	34 (74)	71 (68)
1-2 hours	6 (11)	8 (17)	14 (14)
2-3 hours	2 (4)	Nil	2 (2)
3-4 hours	3 (5)	1 (2)	4 (4)
>4 hours	7 (17)	3 (7)	10 (10)
Total	**55**	**46**	**101**

Mode of transport to hospital			
Ambulance	46 (90)	31 (72)	77 (82)
Private	5 (10)	12 (28)	17 (18)
Total	**51**	**43**	**94**
Optimal management score (/10)*			
Median	7	7	7
Interquartile range	7-8	2.5-8	5-8
Cases ≥8	23 (46)	13 (28)	36 (35)
Total	**56**	**47**	**103**

* Includes only cases with 2 or less missing data points (n=103).

5.5. Discussion

The BokSmart *Safety in the playing environment* document lays out very clear guidelines on field-side medical support and injury management (52). The findings presented in this chapter suggest that widespread implementation of BokSmart training resulted in modest but important changes in the field-side medical management of catastrophic injuries. Furthermore, there have been changes in the level of medical professionals present at the field-side with closer adherence to the BokSmart recommendations.

Specifically, there has been an increase in the number of registered medical care professionals present at the field-side to render medical care in the event of an emergency. These providers are registered with a professional board that regulates the scope of practice through evidence-based clinical practice guidelines. They are trained to a higher level than unregistered first aid providers and are more equipped to recognise and render care to players who may have sustained catastrophic injuries.

In the post-implementation period, a higher proportion of injuries were managed on the field as opposed to off the field. This could indicate that recognition of catastrophic injuries has improved, and players are receiving medical care earlier than if they were managed off the field. This also adds an element of risk mitigation for the injured player as they may not be moved inappropriately, and the injured player can be managed more effectively from the beginning. BokSmart recommends that lay rescuers should not move the injured player especially if spinal injury is suspected (85). The New Zealand Rugby Smart programme has a similar recommendation, it states that the injured player with a suspected ASCI should not be moved until qualified medical personnel arrive (112). With the number of cases being managed on the field, this recommendation is likely being adhered to more frequently.

Sundstrøm *et al.* (2014) found that up to 25% of patients with a spinal injury may have an associated traumatic brain injury (83), thus when managing ASCIs and TBIs, there is evidence supporting the application of spinal motion restriction (SMR) (77,85). The recommended equipment to apply SMR includes a firm board (spinal board, scoop or vacuum mattress) head blocks and a spider harness (77). The rigid cervical collar is optional and controversial, and the decision to utilise or not utilise a rigid cervical collar is the decision of the attending registered medical care professional (85). In the current study, there was an increase in the application of SMR in the post-implementation period. However, the utilisation of rigid cervical collars

decreased slightly in the post-implementation period. This could be attributed to the increased frequency of registered medical care providers being present to assist with the decision on their usage. The majority of the providers were EMS providers and the gold standard in the pre-hospital setting is to limit the usage of rigid cervical collars as there is no evidence to suggest that the application of a rigid cervical collar together with head blocks provides additional benefit to the patient (56,77,85). It has been seen that the rigid cervical collar does not effectively reduce spinal movement and there may be additional movement of the spine by providers applying the rigid cervical collar (83). There is some evidence that the rigid cervical collar may compromise airway management and may cause respiratory restrictions, especially in combination with other spinal motion restriction equipment (83). Additionally, it was found that the rigid cervical collar was only utilised in two TBI cases, this small proportion could be attributed to the fact that rigid cervical collars may lead to an increase in intracranial pressure in the head injured patient due to jugular venous compression and medical personnel could be reluctant to utilise rigid cervical collars (83).

An interesting finding in both periods was that when a spine board was utilised there was a mismatch in the usage of spider harnesses and head blocks. This is a concern as incomplete SMR may put the injured player at risk for further injury. The implication of not using a spider harness in conjunction with head blocks is that there is a risk of sideways movement of the injured player while being carried creating misalignment of the vertebral column (113). Additionally, the injured player may start vomiting and in the event of vomiting the player cannot be safely turned laterally to protect the airway and prevent aspiration (85). This finding represents a key educational point that may be highlighted in future BokSmart training.

In the post-implementation period of BokSmart, there was a decrease in the utilisation of oxygen. This may be attributed to the change in the indications for oxygen usage provided by the Health Professions Council of South Africa (HPCSA). HPCSA pre-hospital clinical practice guidelines recommend that oxygen administration should only be considered in the presence of pulse oximetry (SpO_2< 94%) or respiratory distress (56). However, some evidence exists showing the benefit of oxygen administration in an ASCI (114). Hanson *et al.* (2012) describe providing oxygen to decrease hypoxia and fill respiratory dead space in the unconscious, spinal injured patient. Limiting hypoxia is a key aspect of clinical management in preventing secondary injury to the spinal cord and brain (68,114).

Spineline is a dedicated helpline to assist with the road transport of players who have sustained a serious head, neck or spinal injury (52). It was noted that there was a decrease in the utilisation of Spineline in the post-implementation period. This may be due to several factors related to the increased presence of registered medical care professionals. These practitioners who are predominantly employed by EMS services may therefore contact other services directly to request an ambulance to transport the injured player. In addition, the increased skill and scope of practice in these practitioners may mean that they feel confident to treat seriously injured players without consulting Spineline for support. Alternatively, there may be a lack of awareness in emergency services medics and other stakeholders of the existence of Spineline and the benefits for players without medical insurance. In the CBPJPF/SARU catastrophic injury database some reasons are recorded as to why Spineline was not contacted. Many reasons reflect the factors stated above, another factor was that stakeholders thought Spineline was only for ASCIs and thus did not call Spineline in the event of a TBI or MACE. A recommendation from this study may be to ensure that EMS services providing field-side care at rugby events and other stakeholders are specifically informed of the BokSmart guidelines and the benefits of the Spineline resource for both insured and uninsured patients.

There was a small increase in the post-implementation period in the time it took to transport the injured player to hospital, and this may be associated with the change in the mode of transport to hospital. In the post-implementation period, there was a higher proportion of cases that were transported by ambulance than private vehicle in ASCIs; however, in TBI cases, there was an equal proportion of players transported by ambulance as compared to private vehicle. There is evidence to suggest that transporting the spinal injured patient by ambulance may decrease the incidence of spinal cord lesions and improve outcomes (115). In a Nigerian study of spinal injured patients, it was shown that there was a higher mortality rate in patients who were transported by private vehicle to definitive care (116). While a larger proportion of ambulance transportation is a positive finding, it may impact the waiting time as ambulance availability is fairly limited in the South African setting which has resource limitations.

Interestingly, MACE cases were transported by ambulance in a higher proportion in the post-implementation period, this could be due to better recognition and awareness of the seriousness of the player's condition. It has been shown that access to medical care earlier leads to better outcomes in the event of a MACE such as in the cases of the Danish footballer

and American football player who both suffered cardiac arrest and were successfully resuscitated on the field (91,117).

In order to assess the overall adherence to the recommendations laid out in the *Safety in the playing environment* document (52), we derived an Optimal Management Score. Although there was no significant difference in the Optimal Management Score in the ASCI cases in the pre- and post-implementation periods, there was an increase in the proportion of cases obtaining a score of eight or greater, out of a maximum of 10. An interesting observation was that no cases in the post-implementation period obtained a score of ten, and this may be attributed to the discretion of the registered medical care professional on whether to apply a rigid cervical collar, to administer oxygen and/or to call Spineline.

Despite some improvements in the adherence to the BokSmart recommendations, the distribution of ASCI outcome category did not change significantly following the implementation of the programme. While inappropriate management of the injured player can have devastating effects on the injury outcome (118), it is likely that ASCI outcome is influenced more by the severity of the primary injury than small deviations from optimal management of the injured player.

When categorising ASCIs by those with a permanent outcome compared to those with a non-permanent outcome, we observed higher adherence to SMR application, oxygen administration and contacting Spineline in those ASCIs with a permanent outcome. These differences could be attributed to early recognition of the more obvious signs and symptoms of a catastrophic spinal cord injury presenting in the injured player. It is a positive finding overall that when the injury presents as severe, management decisions tend to adhere more closely to the recommended guidelines. Interestingly, there was a slightly higher proportion of non-permanent cases where the first on-field medical support was a registered medical care professional as compared to permanent outcomes. This could indicate that better training leads to better recognition and more appropriate management of the injured player.

When analysing the time to hospital from initial injury, there was a lower proportion of cases in the less than four-hour window in the permanent outcome as compared to the non-permanent outcome. Similarly, there was a higher proportion of cases with permanent outcomes in the greater than four-hour window to hospital than non-permanent outcome. While there was no significant difference in these categories, it could be suggested that the

cases with permanent outcomes that were delayed by more than four-hours from injury to reach medical care may have had improved outcomes if the delay was less than four hours. There is evidence to suggest that if there is vertebral displacement or dislocation and reduction is performed in less than four hours from injury the outcome may improve (110). There was a significant difference in injured players with permanent and non-permanent outcomes transported by ambulance as compared to private vehicles. Transportation of a spinal injured patient poses a risk of dislocation if the injury is unstable (119). While it may not change the outcome of the injury, it does indicate that the injured player was transported more safely and was receiving medical care while being transported.

5.5.1. Summary

In this chapter, we set out to compare immediate post-injury management in relation to the *Safety in the Playing Environment* Document and *A practical guide to playing smart rugby* in the pre- and post-implementation period. Overall, it can be inferred that, following the implementation of the BokSmart programme, there has been better adherence to the guidelines put forward. There was a higher level of care present in the post- implementation period possibly making the game of rugby safer for participants who experience a catastrophic injury. Quicker transportation times to definitive care by ambulance will mean that injured players are receiving definitive medical care sooner. However, Spineline utilisation was still low in the post-implementation period, this is a valuable resource which could improve access to care for injured players and improve injury surveillance.

Secondly, we set out to determine whether optimal care was associated with improved ASCI outcomes. In the ASCIs where the outcome was permanent, it is likely that the nature of the primary injury was so severe that optimal management could not change the outcome, however, optimal management may mitigate secondary injury and reduce the risk of fatality (110). It may be of value to ensure that registered medical care professionals and lay rescuers are BokSmart trained to ensure that SMR is applied in its entirety to mitigate any unnecessary risk to injured players and in turn optimise the management of players experiencing catastrophic injuries. Additionally, increasing awareness of the value of adhering to BokSmart guidelines in all potentially catastrophic injuries may lead to improved optimal management in all cases even those who present with less obvious signs of severe injury at first presentation.

Chapter 6: Medical care personnel for catastrophic rugby injuries

6.1. Introduction

BokSmart *Safety in the playing environment* document prescribes the level of care that should be provided on the field in the case of injury (52). In the previous chapter, we observed an increase in the proportion of registered medical care professionals present at the field-side compared to lay rescuers following the implementation of the BokSmart programme.

Following the implementation of the BokSmart programme, site audits were carried out at any school, club or stadium that plays rugby. These audits were carried out by BokSmart appointed officials to check adherence with BokSmart requirements (51). While various elements of the prescribed minimum requirements were audited, the levels of care and availability of equipment were scrutinised, and recommendations were made by the auditors. If recommendations were implemented there should be an increase in the level of care and availability of equipment to render effective field-side care. As the CBPJPF/SARU catastrophic injury database has questions referring to the specific levels of care at the field side and management of the catastrophic injury, this chapter will address these factors and analyse the impact of management on outcomes of catastrophic rugby injuries according to the personnel that rendered care to the injured player.

6.2. Objective

The objective of this part was to describe and analyse emergency care personnel levels and its association with immediate post-injury management in South African rugby.

In order to meet this objective, the following will be addressed:

1. To assess whether the level of medical care personnel present at the time of the injury adhered to the prescribed minimum requirements as set out by BokSmart guidelines.
2. To describe and compare the application of SMR in ASCIs and TBIs by different medical care personnel levels.
3. To describe and compare the optimal management score of ASCIs by different medical care personnel levels.

4. To describe and compare ASCI injury outcomes by different medical care personnel levels.

6.3. Methodology

As described in chapter three, all serious rugby injuries in South Africa are required to be reported to the BokSmart Serious Injury Case Manager and are captured in the CBPJPF/SARU catastrophic injury database. This chapter includes a descriptive analysis of the first on-field medical support present at the time of the injury and the immediate post-injury management.

6.4. Results

When analysing the personnel present at the time for all catastrophic injuries, there was an increase in the proportion of registered medical care professionals in the post-implementation period. These professionals included one biokineticist, (1%) in the pre-implementation period as compared to zero in the post- implementation period. In the pre-implementation period, there were 10 (26%) emergency services medics, two (5%) medical doctors, and one (3%) physiotherapist, whereas, in the post-implementation period, there were 23 (37%) emergency services medics; four (6%) medical doctors, and four (6%) physiotherapists.

The lay rescuers included first aiders; 16 (41%) in the pre-implementation period and 23 (37%) in the post-implementation period; and five (13%) rugby medics in the pre-implementation period. There were no rugby medics reported as on-field medical support in the post-implementation period. When analysing the distribution of registered medical care professionals versus lay rescuers present at the time of injury there was no significant difference in the pre- and post-implementation periods using a Chi-squared test (OR=1.9; 95% CI: 0.8-4.4; χ^2=2.109, p=0.146) (Table 6.1).

With regards to the minimum medical requirements for different match categories, there was a 9% increase in the requirements being met in the green level matches in the post-implementation period (pre-implementation: 28 (88%) versus post-implementation: 36 (97%)). Although there was no significant difference between the two time periods (p=0.292).

Table 6.1 Level of medical care personnel present at the time of injury

	Pre-implementation (2008-2011) n (%)	Post-implementation (2012-2019) n (%)	All n (%)
First on-field medical support			
Registered medical care professionals	14 (34)	28 (50)	42 (43)
Lay rescuers	21 (51)	22 (39)	43 (44)
None	6 (15)	6 (11)	12 (12)
Minimum personnel requirements met			
Green	28 (88)	36 (97)	64 (88)
Gold and Gold+	2 (50)	7 (47)	9(12)

There was no significant difference in the level of care present at the time of injury in the various grades of play (Table 6.2) (p=0.061). However, for the school and professional grades of play, there was a larger proportion of registered medical care professionals present as compared to lay rescuers (Table 6.2). The club grade of play had a higher proportion of lay rescuers present at the time of injury. When analysing all catastrophic injuries at school grade of play (n=30), there was a registered medical care professional present in 19 (63%) cases as compared to lay rescuers who were present in 11 (37%) cases. Conversely, injuries at club grade of play (n=52) had a higher proportion of lay rescuers present at the time of injury (31 (60%)) as compared to registered medical care professionals (21 (40%)).

When analysing the proportion of registered medical care professionals as compared to lay rescuers who applied SMR in ASCIs there was no significant difference between the two groups (Table 6.3) (χ^2=3.201, p=0.074). There was a higher proportion of registered medical care professionals (29 (73%)) who applied full SMR compared to lay rescuers (31 (55%)). Registered medical care professionals were 1.96 times more likely to apply full SMR as compared to lay rescuers (95% CI: 0.81-4.71). Similarly, there was no significant difference between registered medical care professionals and lay rescuers for all other categories. However, registered medical care professionals utilised a spine board or stretcher (33 (85%) versus 45 (75%)), a spider harness (19 (74%) versus 32 (59%)), and head blocks (31 (80%)

versus 40 (74%)) in a higher proportion than lay rescuers. Lay rescuers utilised the cervical collar (43 (80%)) in a higher proportion than registered medical care professionals (29 (74%))

Table 6.2 Summary of level of care at various grades of play and activities

	Registered medical care professionals **n (%)**	**Lay rescuers** **n (%)**	**All** **n (%)**
Grade of play at time of injury			
School	19 (42)	11 (25)	30 (34)
Club	21 (47)	31 (70)	52 (58)
Professional	5(11)	2 (5)	7 (8)
Total	**45**	**44**	**89**
Activity at time of injury			
Match	44 (98)	41 (93)	85 (96)
Training	1 (2)	3 (7)	4(4)
Total	**45**	**44**	**89**

While there was a higher proportion of registered medical professionals applying full SMR as compared to lay rescuers, there were a number of cases where incomplete SMR was applied in players who had sustained ASCIs. Of registered medical care professionals, there were five cases that did not apply complete SMR. One (20%) case did not apply both the spider harness and the head blocks; one (20%) case did not apply head blocks and three (60%) cases did not apply a spider harness. Of lay rescuers, 12 cases had incomplete SMR; three (25%) cases did not apply either the spider harness or head blocks, one (8%) case did not apply the head blocks and eight (67%) cases did not apply the spider harness. There were only two (15%) cases where full SMR was applied in TBIs, both cases were managed by registered medical care professionals.

Lay rescuers had a higher proportion of ASCI cases that arrived at the hospital in under four hours, however, registered medical care professionals (34 (87%)) transported injured players to definitive care in less than one hour in a higher proportion than lay rescuers (36 (67%)). Registered medical care professionals had a higher proportion of TBI cases transported to definitive care in less than one hour (4 (31%)). Registered medical care professionals had a

higher proportion of ASCI and TBI cases that were transported by ambulance (32 (82%) and 5 (38%) respectively) and met the criteria of the optimal management score of ASCIs (26 (65%)).

There was no significant difference in the distribution of outcome classification of ASCIs when categorised by the level of care present at the time of injury (Table 6.4) (χ^2=0.598, p=0.440). There was a higher proportion of near-miss cases when registered medical care professionals were present at the time of injury (21 (53%)) as compared to lay rescuers (24 (44%)). There was also no significant difference in the distribution of ASIA classification at one-month post-injury by level of care present at the time of injury (Table 6.3) (χ^2=0.359, p=0.549). However, there was a slightly higher proportion of normal outcomes (ASIA- E) in cases where registered medical care professionals were present (21 (58%)) as compared to lay rescuers (19 (51%)). The outcome of the injury was 1.33 times (95% CI: 0.53-3.34) more likely to have an ASIA-E normal outcome compared to all other ASIA outcome categories in the presence of a registered medical care professional than a lay rescuer.

Table 6.3 Summary of levels of care present and treatment rendered by medical professionals and lay rescuers for all ASCI cases (Complete data only)

	Registered medical care professionals	**Lay rescuers**
	n (%)	**n (%)**
When first attended		
On-pitch	31 (97)	29 (81)
Off-pitch	1 (3)	7 (19)
Total	**32**	**36**
Neck brace/collar used	29 (74)	43 (80)
Placed on stretcher or spinal board	33 (85)	45 (75)
Stabilised with spider harness	29 (74)	32 (59)
Head blocks used	31 (80)	40 (74)
Full spinal motion restriction	29 (73)	31 (55)
Oxygen given	4 (10)	4 (7)
Spineline called	12 (30)	14 (26)
Time to hospital		
Total <4 hours	36 (92)	53 (98)
<1 hour	34 (87)	36 (67)
1-2 hours	2 (5)	11(20)
2-3 hours	Nil	2 (4)
3-4 hours	Nil	4 (7)
>4 hours	3 (8)	1 (2)
Total	**39**	**54**
Mode of transport to hospital		
Ambulance	32 (82)	42 (78)
Private vehicle	6 (15)	10 (19)
Other	Nil	2 (4)
Total	**39**	**54**
Optimal management score (/9)*		
Median	7	7
Interquartile range	6-8	5-7
Cases ≥7	26 (65)	30 (56)
Total	**40**	**54**

* Includes only cases with two or less missing data points (n=95).

Table 6.4 Injury outcome by various levels of care

	Registered medical care professionals **n (%)**	**Lay rescuers** **n (%)**	**All** **n (%)**
Outcome classification			
Fatal	1 (3)	4 (7)	5 (5)
Quadriplegic	10 (25)	13 (24)	23 (24)
Neurodeficit	8 (20)	13 (24)	21 (22)
Near miss	21 (53)	24 (44)	45 (48)
Total	**40**	**54**	**94**
Outcome of injury: ASIA SCALE within 1 month after injury*			
A- Complete: No motor or sensory function is preserved in the sacral segments S4-S5	8 (22)	9 (24)	17 (23)
B-Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5	Nil	1 (3)	1 (1)
C-Incomplete: Motor function is preserved below the neurological level and more than half of the key muscles below the neurological level have a muscle grade of 3 or more	Nil	2 (5)	2 (3)
D-Incomplete: Motor function is preserved below the neurological level, and at least half of the key muscles below the neurological level have a muscle grade of 3 or more	7 (19)	6 (16)	13 (18)
E-Normal: Motor and Sensory function is normal	21 (58)	19 (51)	40 (55)
Total	**36**	**37**	**73**

6.5. Discussion

The BokSmart *Safety in the playing environment* document lays out very clear guidelines on field-side medical support and injury management (52). The findings presented in this chapter suggest that widespread implementation of BokSmart training resulted in changes in the level of medical personnel present at the time of catastrophic injury and in the immediate post-injury management. While the BokSmart programme was compulsory for coaches and referees, it is recommended for all medical personnel participating in Rugby at various grades of play (53).

While there was no significant difference in the personnel present at the time of injury in the pre- and post-implementation periods, there was an increase in the proportion of registered medical care professionals in the post-implementation period present as field-side medical care. This could be related to the stricter implementation of the prescribed minimum medical requirements for the type of match being played in the post- implementation period.

There was an increase in the meeting of these requirements at the green level of play in the post-implementation period, which states that there should be personnel trained in emergency field-side care either a trained first aider or emergency services medics (52). An audit tool is provided by BokSmart for each school, club or rugby body which is to be submitted annually. This may be accompanied by a random site visit by a BokSmart auditor (51). These audits check adherence to requirements at various levels of play and provide the auditor with an opportunity to make recommendations to the school, club, or rugby body.

There was an overall higher proportion of registered medical care professionals present at the time of injury at school grade of play, whereas club grade of play had a higher proportion of lay rescuers present at the time of injury. There was no significant difference in personnel present at the time of injury between the groups for any grade of play. Conversely, in an Irish study of medical personnel provision by Leahy *et al.* (2020), it was reported that school grade of play had a higher proportion of lay rescuers present during rugby matches while club grade of play had a higher proportion of registered medical care professionals (120). Similarly, Anderson *et al.* (2022) found that at school grade of play in Northern Ireland, medical personnel were more likely to be lay rescuers (121). In an English study by Wing *et al.* (2019), they found that at club grades of play, most clubs reported no medical personnel or only a lay rescuer present, they further stated that these clubs did not meet the English Rugby Football

Union prescribed minimum standards (122). It is a positive finding to see that rugby in South Africa is being made safer for younger participants.

In the BokSmart guidelines full spinal motion restriction (SMR) should be applied with a firm board such as a spinal board or vacuum mattress, a spider harness and head blocks (52). There was a 20% difference in the application of full SMR between registered medical care professionals and lay rescuers, in that registered medical care professionals performed SMR in a higher proportion when the player presented with an ASCI. While this is a positive finding, there were several cases where incomplete SMR was performed in both groups of medical care personnel. This is alarming and may pose an increased risk to the patient while being moved off the field as it may allow for lateral movement of an unstable vertebral column further exacerbating the ASCI (113). It is a possibility that there is a lack of equipment available to personnel at the field side and this finding may require further investigation.

Lay rescuers had a slightly higher proportion of ASCI patients transported to hospital in under four hours as compared to the registered medical care professionals. This finding may be linked to the fact that lay rescuers had a higher proportion of patients transported by private vehicle compared to the higher proportion of patients transported by ambulance when in the care of registered medical care professionals. However, registered medical care professionals had the highest proportion of patients transported under an hour to definitive care in both ASCI and TBI. This is a positive finding that may indicate that patients are reaching definitive care earlier and that registered medical care professionals may be better positioned to recognise catastrophic injuries and understand the importance of this time interval.

Overall registered medical care professionals had a higher proportion of optimal management scores of seven or higher for ASCIs compared to lay rescuers. This may be due to better training, better injury recognition and better access to medical equipment, ambulance and hospital resources.

While the level of care present at the time of injury was not ultimately associated with the outcome of the ASCI, registered medical care professionals had higher proportions of near-miss outcome classification, as well as a lower proportion of fatalities. ASCIs can cause significant physiological compromise, deterioration in the patient and possibly death and a lay rescuer may not be able to adequately manage the patient's symptoms in the event of deterioration. There is evidence to suggest that once a neurological deficit is present the

prognosis generally remains poor, and recovery is often limited in the injured person (123). The higher proportion of near-miss outcomes in registered medical care professionals could be attributed to various reasons. These reasons may include better recognition and optimal management of the injury minimising the risk of secondary injury in the patient (110). Another consideration is that registered medical care professionals may have a fear of litigation in the case of a missed catastrophic injury and thus may be over cautious and err towards a diagnosis of an ASCI and thus increased application of SMR and transfer to hospital occurs (79). Additionally in emergency services medics, the scope of practice dictates which providers may apply c-spine clearance and which providers may not (56). This will also increase the number of patients reported as an ASCI until medical staff at hospitals can rule out a diagnosis of ASCI and thus classify the injury as a near-miss. In resource-limited settings the presence of independent practitioners will be limited and thus increased application of SMR and transfer to hospital will occur (79). This may warrant further investigation.

6.5.1. Summary

In this chapter, we set out to investigate the medical care personnel level and the association with immediate post-injury management. Overall, it can be inferred that, following the implementation of the BokSmart programme, there has been better adherence to the prescribed minimum requirements, especially at school grades of play, with registered medical professionals being present in a higher proportion. However, at club grades of play lay rescuers are still present in a higher proportion and therefore not always meeting the prescribed minimum requirements.

There has been an increase in the proportion of the application of SMR in injured players. It was seen that registered medical care professionals tended to transport injured patients in less than an hour to definitive by ambulance in a higher proportion than lay rescuers. While the level of care is not associated with the outcome of a catastrophic ASCI, it has been shown that optimal management occurs more frequently within the registered medical care professionals' group. Further investigation may be warranted into the availability of equipment and more details on the level of care present may be required to identify whether further training of personnel may be required.

Chapter 7: Study discussion

In 2011, BokSmart implemented an educational programme designed to improve injury prevention, surveillance and management. This study aimed to assess if, and how, emergency field-side care was affected following the widespread implementation of the BokSmart programme, using the CBPJPF/ SARU catastrophic injury database to compare catastrophic injury epidemiology, field-side management, and medical care personnel profiles before and after its implementation.

7.1. Epidemiology of catastrophic injuries

The main finding of this study was that following the implementation of the BokSmart programme in 2011, there has been a decrease in the mean number of catastrophic injuries per year specifically in the incidence of acute spinal cord injuries (ASCI). Worldwide, several injury-prevention programmes have been implemented in an effort to decrease the incidence of catastrophic injuries in rugby. Evidence from Ireland, New Zealand, England and Australia has shown that injury surveillance is important in injury prevention (38,124) and programmes like Smart Rugby (Australia) and Rugby Smart (New Zealand) have resulted in a successful decrease in the number of catastrophic injuries in the game of rugby (124). In South Africa, BokSmart has shown similar success. Freitag *et al* (2015) found that New Zealand and South Africa are the only countries to have implemented all aspects of the injury prevention programmes (124). Reducing the frequency of catastrophic injuries will lessen the burden on both the individual and the healthcare system. This is especially important when considering school grades of play where participants have their whole lives ahead of them (125).

Notably, there has been a decrease in the mean number of ASCIs and traumatic brain injuries (TBIs) per year at all grades of play. Whereas major adverse cardiovascular events (MACE) increased at club grades of play. This is consistent with international data, which found that MACE generally occurred in older athletes (>35 years of age) as compared to younger athletes (126,127). Post the implementation of BokSmart it is likely that players, coaches and support staff are more aware of MACE and are therefore more likely to report these events.

Prior to the implementation of the BokSmart programme, the scrum was the event associated with the highest number of injuries. After the scrum law changes in 2012, there was a significant decrease in the number of catastrophic injuries occurring worldwide resulting from

a scrum (34). In the current study, the tackle was associated with the highest proportion of catastrophic injuries. There has been a shift in injury prevention focus to safer tackling with more emphasis on training coaches and players on tackling technique (103,108).

Despite the large number of registered players in South African rugby, 405 438 registered in 2020 (128), the mean number of catastrophic injuries per year has declined during the study period. This starts to provide evidence that the BokSmart programme is effective in its primary goal of reducing injury incidence (50). In a previous evaluation of the BokSmart programme by Brown *et al.* (2016), it was found that there was a decrease in the mean number of catastrophic injuries in junior players but not in senior players (16). They hypothesised that this was due to resistance to implementing a new programme by experienced coaches, referees and players. The findings in this study show that there has been a decrease in the mean number of catastrophic injuries per year at all grades of play. This could imply that the BokSmart programme has been implemented more effectively, injury prevention may be more successful and potentially met with less resistance.

Although we can see modest improvements in catastrophic injury frequency, this study has shown that injury prevention programmes may result in subtle improvements in care when catastrophic injuries do occur.

7.2. Field-side management of catastrophic rugby injuries

Following the implementation of BokSmart, there has been an increase in the number of registered medical care professionals providing post-injury management on the field at the time of a catastrophic injury. For catastrophic injuries that occurred during club grades of play, there were lower proportions of registered medical care professionals present when compared to school grades of play. The presence of registered medical care professionals has a cost implication, and it could be that socio-economic factors dictate the level of care that could be present at club grades of play. South Africa is classified as an upper middle-income nation (16,129) and it has been shown that access to medical care and resources can be limited (23). In Ireland, a high-income nation (129), Leahy *et al.* (2020) found there was disparity in the availability of medical personnel based on the resources available in schools (120). An Irish study of amateur club rugby by Coughlan *et al.* (2014), found that coaches or other team officials with first aid qualifications were utilised as designated medical personnel and did not have dedicated medical personnel available (130). Additionally, they found that

when the coach or other team official was appointed as designated medical personnel, they may not have had the required knowledge or expertise to ensure that adequate or correct equipment and resources were available for immediate post-injury management (130). It has been suggested by Coughlan *et al.* (2014) that the success of an injury prevention and management programme depends on the availability of resources including dedicated medical personnel and training of all stakeholders involved (130). These findings show that even in well-resourced nations resource limitations are occurring, and it is a positive finding that in South Africa, a low resource setting, despite resource limitations there has been an increase in the number of registered medical care professionals present at the field-side providing post-injury management.

Injury outcomes have been shown to be better in the presence of professional first responders compared to lay rescuers. Badenhorst *et al.* (2019) found that in ASCI cases analysed from the CBPJPF/SARU catastrophic injury database, where there was no medical care personnel or only lay rescuers present, inappropriate post-injury management often occurred with catastrophic outcomes (125). A study by Ko *et al* (2018) found that prehospital cardiac arrest during exercise had better outcomes when witnessed by first responders rather than lay rescuers (90). In the last three years cases of athletic cardiac arrest has been seen in football (91) and more recently in American football (117) where players suffered sudden cardiac arrest (SCA) and were resuscitated by first responders with successful outcomes. The American footballer's cardiac arrest was linked to a tackle event. The BokSmart guidelines require registered medical care professionals to be present at the field-side and the findings in this study show that there is better adherence to these guidelines with potentially better post-injury management in the event of a catastrophic injury occurring.

A further recommendation from the BokSmart guidelines includes contacting Spineline in the event of a catastrophic injury. A concerning finding in this study was the low proportion of cases in which Spineline was contacted. This could be due to medical personnel and other stakeholders being unaware that Spineline is part of the *Serious injury protocol* and is available for all catastrophic injuries, not just ASCIs. This may allude to a greater issue of medical personnel not being BokSmart certified and unaware of the procedures recommended by BokSmart. Many registered medical care professionals may be associated with a specific emergency medical care service provider and therefore may be unwilling to utilise the BokSmart aligned medical service. Whilst this study found that injured players are being

transported in a higher proportion by ambulance in the post-implementation period, contacting Spineline may make ambulance transport available more timeously to injured players even in resource-limited settings. Spineline is a resource that will assist injured players to receive ambulance transportation to an appropriate medical facility and the low usage could delay transportation and ultimately worsen the outcome of the injured player.

In this study, it was found that there was better adherence to BokSmart guidelines with spinal motion restriction (SMR) being utilised more often, however, the application of SMR is often incomplete. This is concerning as it adds additional risk to the injured player. In a study by Markowitz and Woods (2021), it was found that up to 25% of ASCIs are worsened by inappropriate care by medical professionals (76). Incomplete SMR may allow for excessive movement and potentially cause secondary injury to the spinal cord in the presence of an unstable vertebral column (76).

Despite better adherence to the BokSmart guidelines, there was no significant impact on the outcome of ASCIs, most likely due to the severity of the initial insult to the spinal cord (123). It was seen that the more severe injuries (permanent outcomes) had better adherence to the BokSmart guidelines. In this study, we found subtle shifts in the lasting morbidity at one month which indicates that improved care may reduce the likelihood of exacerbating the original injury and result in slightly improved morbidity outcomes.

The implementation of the BokSmart programme may have improved awareness of the risk of catastrophic injury and that, together with the increase in registered medical professionals at the field side, may have resulted in quicker identification of serious injuries and better adherence to management guidelines. These registered medical care professionals see such injuries more often than lay rescuers and are therefore able to identify them quicker.

7.3. Medical care personnel for catastrophic rugby injuries

With regards to on-field medical support, there was an increase in the proportion of cases in which registered medical care professionals provided post-injury management, which meets the prescribed minimum standards as prescribed by BokSmart. However, at club grades of play, there was still a larger proportion of lay rescuers rendering field-side care. Registered medical professionals rendering field-side care showed an increase in optimal management of injured players with better adherence to management guidelines. Notable improvements

included quicker transport times to hospital by ambulance as opposed to by private vehicle. This is a positive finding as it shows that injured players are remaining in the care of registered medical care professionals while being transported to hospital as opposed to an interruption in care if they were transported by private vehicle.

While SMR was applied more often by registered medical professionals, there were several cases where incomplete SMR was applied. More training may be required for registered medical professionals and lay rescuers providing post-injury management at the field side to ensure that full SMR is utilised in every catastrophic injury requiring SMR. While there were more cases with optimal management, the outcome of the ASCI was not affected by the immediate post-injury management or the level of care providing post-injury management. This could be due to the severity of the primary insult to the spinal cord.

Overall schools had the highest adherence to the green level prescribed minimum requirements. With meeting the prescribed minimum requirements, it shows that there was a higher proportion of registered medical professionals rendering optimal management in the event of a catastrophic injury occurring. It could also imply that school grades of play have BokSmart certified personnel and are more familiar with the injury prevention recommendations and injury management guidelines. This is a heartening observation that alludes to the value that the rugby community places on safety for younger participants.

7.4. Study limitations

A limitation of this study was the small sample size specifically the small sample of TBIs and MACE. Some of the data from the CBPJPF/ SARU catastrophic injury database was incomplete and therefore had to be excluded further decreasing the sample size.

Another limitation of the study design is that we could not account for the severity of the initial injury when analysing the difference between the pre- and post-implementation periods of the BokSmart programme or in the different grouped analyses of outcomes. By nature, the injuries were highly variable and not able to be categorised in terms of the severity of the initial injury without more clinical data from first responders. This is an avenue for future research. The nature of the study design also limited the ability to show causality between risk factors and injury outcomes.

7.5. Conclusion

Following the full implementation of the BokSmart programme there has been a marked decrease in the mean number of catastrophic injuries per year with positive changes in the field-side treatment. Overall, there has been a decrease in the occurrence of ASCIs and TBIs with better optimal management in accordance with the BokSmart guidelines. There has been an increase in the reporting of MACE in the post-implementation period specifically at club grades of play. Specific law changes such as those related to the scrum have made that phase of play safer for players at all grades of play.

While the outcome of an ASCI may not be appreciably improved by immediate post-injury management, the increased presence of registered medical care professionals showed improved adherence to the BokSmart serious injury protocols. A concern was the proportion of cases with incomplete SMR utilisation and the lack of utilisation of Spineline which is a valuable resource in the event of any catastrophic injury. Overall school grades of play met BokSmart prescribed minimum requirements in a higher proportion than club grades of play. This implies that the game of rugby has become safer for young participants.

BokSmart has shown to be effective through its educational programmes and injury surveillance, management and reporting guidelines, to not only improve and optimise emergency field-side care but also to reduce the average number of catastrophic injuries per year across all grades of play in rugby.

7.6. Recommendations and future research

It should be ensured that all medical personnel providing on-field medical support during rugby training and matches, including registered medical care professionals, are BokSmart certified. This will ensure that personnel are up to date with the latest guidelines and allow for more optimal management of players. It will also inform personnel of the correct protocols to follow in the event of a serious injury such as contacting Spineline. Emergency medical care providers are trained to recognise high force mechanisms of injury and may not be aware of the nuances of sports-related injuries. It may be a necessity, in addition to the BokSmart certification, to have sports specific training programmes for pre-hospital providers as the patient population is different and the mechanisms of injury are different to those of the wider pre-hospital environment.

MACE at the club grade of play is concerning and may warrant further investigation into the barriers to providing professional levels of care which will assist to improve recognition and immediate post-injury management. Pre-season audits of the venue, medical facilities and resources, and pre-screening of players at all grades of play may be of value in improving player safety and ensuring better adherence to BokSmart guidelines. This may additionally illicit readiness of the school or club to manage MACE and other catastrophic injuries including the availability of equipment such as a defibrillator or automated external defibrillator (AED).

Many of the cases in the CBPJPF/ SARU catastrophic injury database were incomplete, the adoption of an online reporting system to give BokSmart real-time feedback and make the submission of BokSmart serious injury forms quicker could be of value (131). The inclusion of the level of qualification of the medical personnel such as whether it was a basic life support (BLS) practitioner or an advanced life support (ALS) practitioner in the serious injury report form will provide more clarity on the management that was carried out as their scopes of practice and capabilities of these categories of practitioner are vastly different and will change the management of the injured player.

Future research opportunities are to investigate the nature and severity of the initial injury from first responders to determine causality between risk factors and injury outcomes.

Most MACE cases are only reported 24-48 hours after the match or training activity. It may be of value to investigate causality between participating in rugby and MACE in the period following participation.

With regards to the large proportion of near-miss ASCI outcomes, it may be of value to investigate whether medical personnel are appropriately referring injured players or whether there are factors such as fear of litigation or limited scope of practice dictating referral to hospital for players with potential ASCIs.

With regards to medical personnel applying SMR in the event of an ASCI or TBI, it may be warranted to investigate the equipment availability, utilisation and confidence when applying SMR.

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Appendices

Appendix A: BokSmart Serious Injury Follow-up Form

Serious Injury Report Follow-up Questionnaire

A serious and/or catastrophic injury is defined 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.

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, **Mrs. Gail Baerecke – Cell: 0728903538, e-mail: manager@playersfund.org.za, fax: 021 659 5653**
- 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's Senior Manager: Medical and SARU's Senior Manager: Rugby Safety

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

WORLD RUGBY (WR) (FORMERLY KNOWN AS 'INTERNATIONAL RUGBY BOARD' OR 'IRB')

All data collected will be forwarded anonymously to WORLD RUGBY and stored in a secure WORLD RUGBY database of catastrophic injuries. These data may be analysed by WORLD RUGBY 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 WORLD RUGBY, and be used by both SARU and WORLD RUGBY 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

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):

_____ _____

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

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:

_____
_____
_____
_____
_____
_____

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): _____

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

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

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 WORLD RUGBY 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: _____

f. Had the coach attended a SARU or WORLD RUGBY 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

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>*

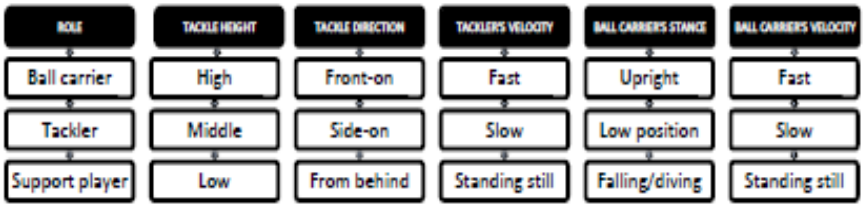
a. What was the injured player's role in the tackle?

- ☐ 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

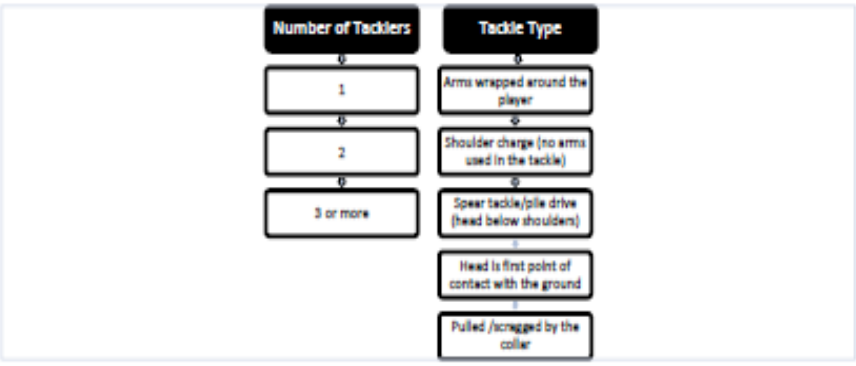
b. What type of contact was involved?

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

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



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



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

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?

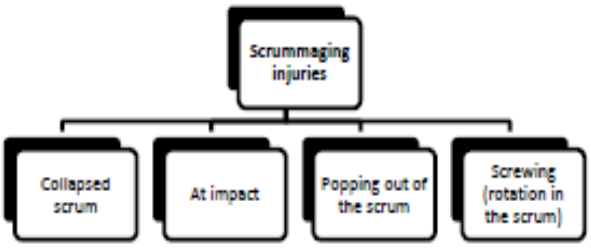
Injured player's team	Opposition team
☐ 3	☐ 3
☐ 5	☐ 5
☐ 6	☐ 6
☐ 7	☐ 7
☐ 8	☐ 8

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



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

_____
_____
_____
_____

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.

_____
_____
_____
_____

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)_____

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 removal of the player from the pitch (was in charge/helped out)?

☐ 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 *leave* the field at any time during the match *before* the injury and *return* to the field of play?

☐ Yes ☐ No

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?

_____
_____
_____

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 WORLD RUGBY Level coaching course?

☐ Yes ☐ No

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 coaching for his/her position by a qualified coach?

☐ Yes ☐ No

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

☐ Yes ☐ No

43. How long before the season did the player take part in pre-season 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 pre-season 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 _____

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 neck 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

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

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
☐ Dry
☐ Light Rain
☐ Overcast
☐ Cold
☐ Heavy Rain
☐ Windy
☐ 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?

_____
_____
_____

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

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?

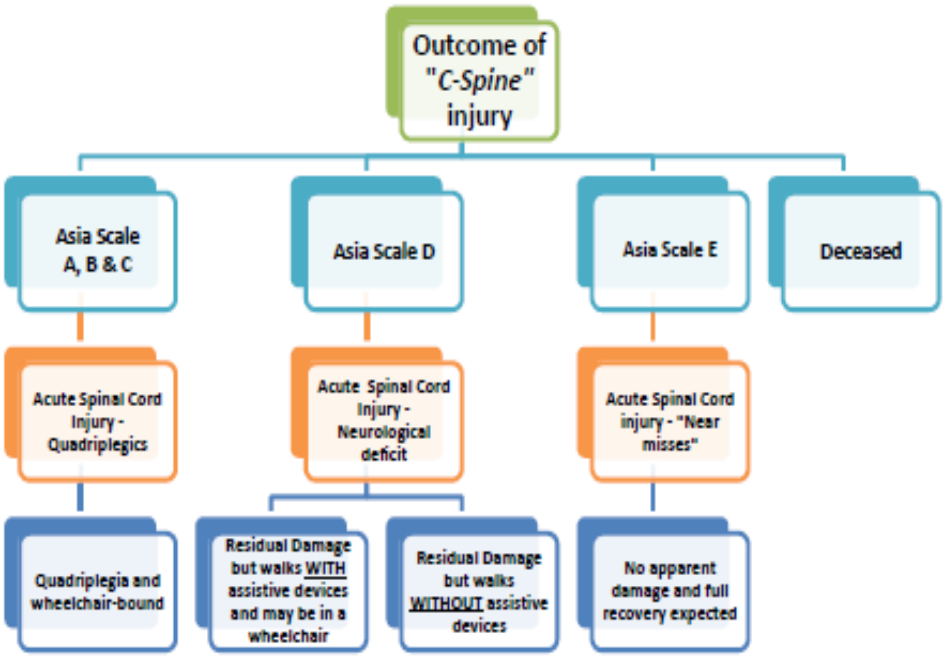
_____
_____
_____

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

_____
_____
_____

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:_____

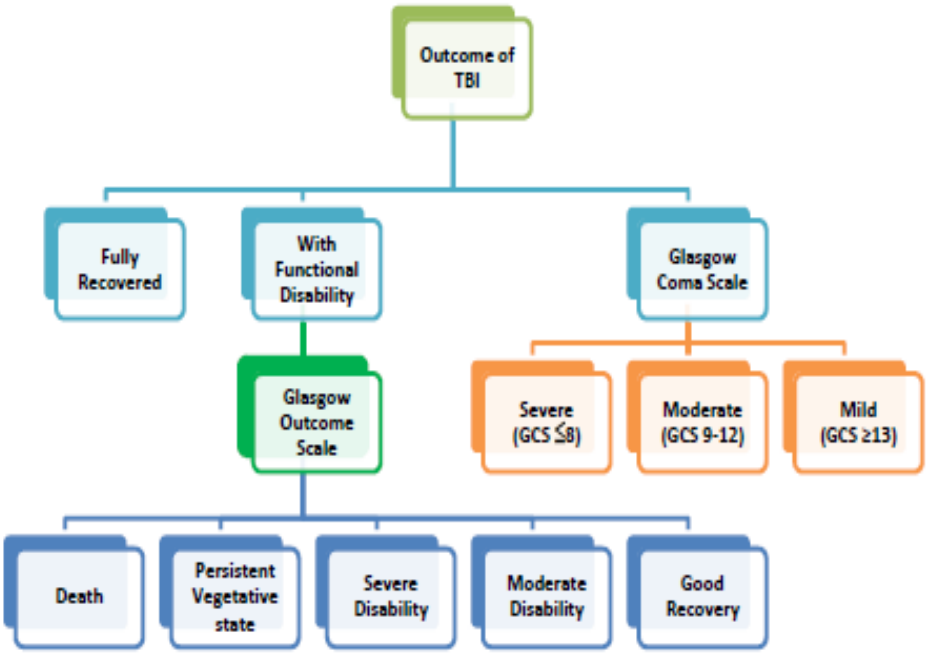
☐ Non-fatal Spinal Cord Injury
- ☐ Quadriplegia and Wheelchair bound
- ☐ Potential catastrophic injury with recovery (residual damage but walks with assistive devices and may be in a wheelchair)
- ☐ Potential catastrophic injury with recovery (residual damage but walks without assistive devices)
- ☐ No apparent residual damage and full recovery expected

☐ 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



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:

_____
_____
_____

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:

_____
_____
_____

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:

_____
_____
_____

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:

_____

_____

_____

Appendix B: Ethical Approval

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

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

05 February 2021

HREC REF: 736/2020

Dr C Saunders
Division of Emergency Medicine
F-51, OMB
Email: colleen.saunders@uct.ac.za
Student: dsslid001@myuct.ac.za

Dear Dr Saunders

PROJECT TITLE: FIELD SIDE MANAGEMENT OF SERIOUS INJURIES IN CONTACT SPORTS ACTIVITIES IN SOUTH AFRICA-MSC CANDIDATE-LIDIA GREEN-STUDY 1

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

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020 & 06 July 2020.

Approval is granted for one year until the 28 February 2022.

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)

The HREC acknowledge that the student: - Lidia Green will also be involved in this study.

Please quote the HREC REF 736/2020 in all your correspondence.

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

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

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

HREC/REF 736/2020sa

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938)			
This serves as notification of annual approval including any documentation described below.			
☑ Approved	Annual progress report	Approved until/next renewal date	28/02/23
☐ Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee		Date Signed	6/3/2022

Note: Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.
Please clarify your plan for research-related activities during COVID-19 lockdown.
Please use the latest form found on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol Information

Date (when submitting this form)	3 March 2022		
HREC REF Number	054/2021	Current Ethics Approval was granted until	2022/02/28
Protocol title	Field side management of serious injuries in contact sports activities in South Africa: Field side management of serious injuries in contact sports activities in South Africa: Application and adherence to the BokSmart Serious Injury Protocol (Study 2)		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?		✓ Yes	☐ No
If yes, could you please provide the HREC Reference number for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study.		HREC 055/2021	
Principal Investigator	Dr Colleen Saunders		

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

UNIVERSITY OF CAPE TOWN FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) This serves as notification of annual approval including any documentation described below.			
☑ Approved	Annual progress report	Approved until/next renewal date	28/02/23
☐ Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee		Date Signed	6/3/2022

Note: Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.
Please clarify your plan for research-related activities during COVID-19 lockdown.
Please use the latest form found on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol Information

Date (when submitting this form)	3 March 2022		
HREC REF Number	055/2021	Current Ethics Approval was granted until	2022/02/28
Protocol title	Field side management of serious injuries in contact sports activities in South Africa: Changes in injury management following implementation of the BokSmart programme (Study 3)		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?		☐ Yes	✓ No
If yes, could you please provide the HREC Reference number for all sub-studies? **Note:** A separate FHS016 must be submitted for each sub-study.		N/A	
Principal Investigator	Dr Colleen Saunders		

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)