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Tackle-related injury rates and nature of injuries in national Youth Week rugby union tournaments in South Africa (under-13 to under-18)

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> 28 Abstract 29 **Objectives** 30 The tackle situation is most often associated with the high injury rates in rugby union. Tackle 31 injury epidemiology in rugby union has previously been focused on senior cohorts but less is 32 known about younger cohorts. The aim of this study was to report on the nature and rates of 33 tackle-related injuries in elite South African youth rugby union players. 34 Design 35 36 Observational cohort study. 37 38 Setting 39 Four South African Youth Week tournaments (under-13 Craven Week, under-16 Grant 40 Khomo Week, under-18 academy Week, under-18 Craven Week). 41 42 **Participants** Injury data were collected from 3652 youth rugby union players (population at risk) in 2011 43 and 2012. 44 45 46 **Outcome measures** 47 Tackle-related injury severity, type and location, injury rate per 1000 hours (including 95% 48 confidence intervals). Injury rate ratios were calculated and modelled using a Poisson 49 regression. A chi-squared analysis was used to detect linear trends between injuries and 50 increasing match quarters. 51 52 Results 53 There was a higher probability of 'overall' and 'time-loss' tackle-related injuries occurring at

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54	the under-13 Craven Week. The under-13 Craven Week had a significantly greater 'time-
55	loss' injury rate when compared to the 2012 under-18 Craven Week (IRR: 3.52; 95%CI:
56	1.54-8.00, p<0.05). The under-13 Craven Week also had the greatest proportion of broken
57	bone/factures and muscular injuries for both 'overall' (12% and 23%) and 'time-loss' injuries
58	(28% and 22%). The proportion of 'overall' injuries increased significantly with each quarter
59	of the match when all four tournaments were combined (p<0.05).
60	
61	Conclusions
62	Age and match-related fatigue may affect the rates and nature of tackle-related injuries in
63	youth rugby union. On-going injury surveillance is required to interpret these findings. Injury
64	prevention strategies targeting the tackle may only be effective once rate and nature of the
65	injuries have been determined.
66	
67	Key words: youth: injury epidemiology: rugby union: tackle.
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69	Strengths and limitations of this study
70	• This study is novel as it reports specifically on tackle-related injury rates and nature
71	of injury in elite South African youth rugby union players
72	Findings may help identify tackle injury prevention strategies for other youth rugby
73	union players
74	Findings may help prepare medical professionals for injury assessment and
75	management at youth rugby union tournaments
76	Only injuries reported to the tournament doctor were included in the analysis
77	Findings in this study should not be generalised as the analysis involved a specific
78	cohort of players at a week-long tournament
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81 Introduction

Rugby union is a team sport played worldwide and characterised by frequent contact
situations between players.¹⁻³ The ability to tolerate and contest these situations is a
prerequisite for participation and success in the sport.^{2,4,5} The high frequency of contact
situations places rugby players at higher risk of injury when compared to other team
sports.^{6,7} In particular, the tackle is the contact event most often associated with this high
rate of injury.⁸⁻¹⁰

The tackle is defined as "any event where one or more tacklers (player or players making the tackle) attempt to stop or impede the ball-carrier (player carrying the ball) whether or not the ball-carrier was brought to ground".^{5,10} The tackle is an effective way to try and regain possession of the ball, and to prevent the attacking team from gaining field territory and advancing into a point-scoring position.⁵

Tackle-related injury rate has previously been reported for both league and tournament formats in professional English Premiership rugby⁸ and at the Rugby World Cup,¹¹ respectively. The tackle is responsible for a high proportion of upper-body injuries in tacklers, particularly concussion, head/neck and shoulder injuries, and ball-carriers are more likely to sustain injuries to the lower-body, particularly thigh muscle and knee injuries.^{8,9,12} Despite the plethora of tackle injury studies with a focus on senior rugby union players.^{9,10,14} less is known about youth cohorts. Therefore, the aim of this study was to report on the nature and rates of tackle-related injuries occurring at four elite youth rugby union tournaments which were hosted by the South African Rugby Union (SARU) in 2011 and 2012. It is noteworthy that this study is unique in comparison to previous research as these tournaments span for one week only.

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The specific questions of this study, pertaining to tackle-related injuries at youth rugby union tournaments, are as follows; (1) are injury rates comparable across the age categories (13 to 18 years), (2) do injury type proportions differ across the age categories, (3) do injuries occur at different anatomical locations for ball-carriers and tacklers, and (4) does the rate of injury events increase with match time? The answers to these questions may contribute to the development and implementation of targeted injury prevention and management strategies in youth rugby.

- 116 Methods

SARU coordinates an injury-surveillance project, via the BokSmart National Rugby Safety Programme,¹⁵ whereby information about all injuries that occur at their Youth Week tournaments are recorded and transcribed into an injury database. Authors were granted access to this database for analysis by SARU and the UCT Human Research Ethics Committee (HREC Ref: 438/2011). All players attending the Youth Week tournaments and their parents/legal guardians signed the SARU Medical and Anti-Doping informed consent form which has a section dedicated to explaining the details of the injury-surveillance project. When a player was injured, informed consent to analyse the recorded information was once again confirmed by the player or by the player's parent or guardian. The Youth Week tournaments are a showcase for South Africa's most talented schoolboy players and include the under-13 Craven Week, under-16 Grant Khomo Week, under-18 Academy Week and under-18 Craven Week tournaments. These tournaments are unique in that they only span the course of one week and thus place increased physical demands on players. Participating teams are formed through the selection of the top schoolboy players from within each of the country's 14 provincial rugby unions in addition to one Namibian and one Zimbabwean team. In the case of the two under-18 tournaments, Craven Week involves the best schoolboy players from each union, while the Academy Week involves the second tier of players from each union.

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A SARU-appointed doctor was on duty at each tournament to assess every injury that
occurred. Details about each injury were recorded on an injury collection form that was
designed based on the Consensus Statement for injury surveillance.¹⁶ Only data pertaining
to the tackle event were analysed for the purposes of this study.

The injury definition for these tournaments, adapted from the Rugby Union injury Consensus Statement,¹⁶ was stated as '*any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match and required attention from the SARU tournament doctor'.*

'Time-loss' and 'medical attention' tackle-related injuries were reported for this study. A 'time-loss' injury was an injury (based on the aforementioned definition) that resulted in the player being absent for more than one match in a tournament, or more than one day of normal/planned recreational activities during or after the tournament. Injuries were confirmed as *'time-loss'* injuries during the course of the tournament or via telephonic follow-up after the tournament. Weekly phone calls were made to assess the state of the injury until the player returned to practice. 'Medical attention' injuries required treatment from the tournament doctor, but resulted in no loss in recreational, play or practice time. 'Overall' injuries included both 'medical attention' and 'time-loss' injury events. Due to the short duration of each tournament and low absolute injury numbers, 'medical attention' injuries were included during the analyses, as important information may have been overlooked if only 'time-loss' injury data were considered.7

159 The '*type*' of injury was categorised as either concussion, spinal cord, broken bone/fracture, 160 joint/ligament/tendon, muscle, bruise, laceration (including skin abrasion), or other by the

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tournament doctor. If the tournament doctor was unable to diagnose the injury at the time, the injury 'type' was recorded as 'unsure'. The 'location' of the injury was categorised into an anatomical group; head/neck, upper torso, upper limb, lower torso, lower limb, or 'unsure'. Statistical analysis Player exposure time was calculated for all 2011 and 2012 tournaments based on the current injury collection consensus statement for rugby;¹⁶ *Exposure time* = $N_M \times P_M \times D_M$ For this calculation, N_M is the number of matches, P_M is the number of players per match (i.e. 30 players from both sides), and D_M is the duration of the match in hours. This exposure time

was used to determine the injury rate and corresponding 95% confidence intervals (95%

173 Cls) for the number of tackle-related injuries per 1000 hours of match play regardless of

174 whether a player was injured more than once.¹⁷

The injury rate ratios (IRR) and corresponding 95% CIs were calculated¹⁸ to determine the difference in injury rates across the age categories (each year was analysed separately). The IRR was calculated by dividing the injury rate of one tournament, for example year '*A*' (numerator), by its total player exposure time, and then dividing this by the equivalent value for the specific tournament to which it was compared, for example year '*B*' (denominator);

 $IRR = \frac{injury \, rate_A / exposure_A}{injury \, rate_B / exposure_B}$

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The standard error (SE) of the log of the IRR was calculated by dividing the total number of tackle injuries of each of the two compared tournaments (*y*) by one, and finding the square root of their sum;

$$SElogIRR = \sqrt{\frac{1}{y_A} + \frac{1}{y_B}}$$

187 Confidence intervals (95%) were then calculated by using the log of the IRR and the SE of
188 the log;

95%CI = $logIRR \pm 1.96 \times SElogIRR$

The IRR was considered significantly greater for the numerator if both 95% CIs were greater than 1.0. Conversely, an IRR was considered significantly lower for the numerator if the both 95% CIs were less than 1.0.

Significant findings from the IRR analysis were verified using VRP injury statistics software
(University of North Carolina, Injury Prevention Research Center).¹⁹ The IRR between any
two tournaments was only considered to be significant if the VRP analysis yielded a p-value
of less than 0.05.

A Poisson regression was modelled using STATA 11.1 (StataCorp LP, USA) to determine
the probability of injury across the age categories (both years were combined and the
under-18 Craven Week tournament was used as the reference i.e. denominator). The year

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of the each tournament was factored into the model (2011 was used as the reference i.e.	J Ope	
denominator) even though this was not part of the main analysis.		
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A chi-squared analysis was conducted using GraphPad Prism 5 (version 5.02 for Windows)	shed as Pro	
to determine whether there were any significant linear trends (p<0.05) between the	10.11: tectec	
proportion of tackle-related injuries occurring in each match quarter for all tournaments	36/bm I by c	
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Results	-005556 cluding	
Injury surveillance was conducted on 1804 players in 2011 and on 1848 players in 2012	on 12 for us	
(Table 1) Sixty per cent of 'every l' injuries (Table 2) from 2011 and 2012 (n = 262 of 440	? Augu ses re	
(Table T). Sixty per cent of overall injuries (Table 2) from 2011 and 2012 (II – 203 of 440	ust 20 Pated	
Injuries) were tackie-related injuries. Sixty-one per cent of overall tackie-related injuries	114. D to tey	
were to the tackler and 39% were to the ball-carrier. Fifty-nine per cent of all 'time-loss'	ownlo ogesc (t and	
injuries (Table 2) from 2011 and 2012 (n = 104 of 176 injuries) were associated with the	hool I data	
tackle. Sixty per cent of tackle-related 'time-loss' injuries were to the tackler and 40% were to	minii	
the ball-carrier.	ng, Al	
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The 'overall' tackle-related injury rates at the 2011 tournaments were 29.2 injuries per 1000	n May techno	
exposure hours (95%CI: 16.8-41.6) at under-13 Craven Week, 24.7 injuries per 1000	/ 22, 2 ologie	
exposure hours (95%CI: 13.9-35.5) at under-16 Grant Khomo Week, 34.4 injuries per 1000	8. S.	
exposure hours (95%CI: 24.6-44.3) at under-18 Academy Week, and 23.8 injuries per 1000	t Dep	
exposure hours (95%CI: 14.5-33.1) at under-18 Craven Week (Figure 1A). The 'overall'	artme	
tackle-related injury rates at the 2012 tournaments were 50.0 injuries per 1000 exposure	int GE	
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hours (95%CI: 33.7-66.3) at under-13 Craven Week, 36.7 injuries per 1000 exposure hours
(95%CI: 24.2-49.2) at under-16 Grant Khomo Week, 34.4 injuries per 1000 exposure hours
(95%CI: 24.6-44.3) at under-18 Academy Week, and 33.5 injuries per 1000 exposure hours
(95%CI: 22.2-44.8) at under-18 Craven Week.

Analysis of tackle-related 'time-loss' injury rates of the 2011 tournaments showed 11.1 injuries per 1000 exposure hours (95%CI: 3.4-18.8) at under-13 Craven Week, 9.9 injuries per 1000 exposure hours (95%CI: 3.0-16.7) at under-16 Grant Khomo Week, 18.3 injuries per 1000 exposure hours (95%CI: 11.1-25.5) at under-18 Academy Week, and 10.5 injuries per 1000 exposure hours (95%CI: 4.3-16.7) at under-18 Craven Week (Figure 1B). The tackle-related 'time-loss' injury rates of the 2012 tournaments showed 22.2 injuries per 1000 exposure hours (95%CI: 11.3-33.1) at under-13 Craven Week, 13.3 injuries per 1000 exposure hours (95%CI: 5.8-20.9) at under-16 Grant Khomo Week, 11.0 injuries per 1000 exposure hours (95%CI: 5.4-16.6) at under-18 Academy Week, and 8.9 injuries per 1000 exposure hours (95%CI: 3.1-14.7) at under-18 Craven Week.

The Poisson regression model revealed no significant differences in 'overall' and 'time-loss' tackle-related injury rate across the age categories when both years were combined. However, there was a higher probability of 'overall' tackle-related injury at the under-13 Craven Week when compared to the under-18 Craven Week (IRR: 1.38; 95%CI: 0.96-1.99, p=0.08). Tackle-related *time-loss* injury also had a higher probability of occurring at the under-13 Craven Week when compared to the under-18 Craven Week (IRR: 1.72; 95%CI: 0.95-3.12, p=0.07). There was a significantly higher chance of incurring an 'overall' tackle-related injury in 2012 when compared to 2011 (IRR: 1.31; 95%CI: 1.03-1.67, p<0.05).

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2 3	253	There were no significant differences when 'overall' and 'time-loss' tackle-related IRRs were
4 5	254	calculated for the 2011 tournaments. However, there was a significantly greater tackle-
6 7	255	related 'time-loss' injury rate at the 2012 under-13 Craven Week tournament when
8 9	256	compared to the 2012 under-18 Craven Week (IRR: 3.52; 95%CI: 1.54-8.00, p<0.05). This is
10 11 12	257	consistent with the result from the Poisson regression (see above).
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16 17	259	(Insert Figures 1A and 1B)
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19	260	
20 21	261	The largest proportion of 'overall' tackle-related injuries were joint/ligament/tendon 'type'
22 23 24	262	injuries (29%), bruise/contusions (21%), muscle injuries (15%), concussions (11%), and
24 25 26	263	lacerations (10%) when all tournaments in 2011 and 2012 were combined. The greatest
27 28	264	proportion of tackle-related 'time-loss' injuries were joint/ligament/tendon injuries (32%),
29 30	265	concussions (27%), muscle injuries (12%), and broken bone/fractures (12%). The under-13
31 32	266	Craven Week tournament had the greatest proportion of broken bone/factures and muscle-
33 34	267	related injuries for both 'overall' (12% and 23% respectively) and 'time-loss' injuries (28%
35 36	268	and 22% respectively) when 2011 and 2012 were combined.
37		
38 39	269	
40 41	270	When observing anatomical injury locations, 40% of 'overall' tackle-related injuries to the
42 43	271	tackler across all four tournaments in both years, were head/neck injuries. Upper torso
44 45	272	injuries (24%) were the next most frequent in tacklers followed by lower limb (17%) and
46 47	273	upper limb (16%) injuries. The majority of tackle-related 'time-loss' injuries to tacklers across
48 49	274	all four tournaments in both years, were head/neck (45%) followed by upper torso (26%),
50 51 52	275	lower limb (19%) and upper limb (10%) injuries.
53 54	276	
55 56	277	In contrast, the majority of ball-carrier 'overall' tackle-related injuries were lower limb (44%)
57 58 59	278	followed by head/neck (26%) and upper torso (22%) injuries. The highest proportion of

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tackle-related *'time-loss'* injuries to ball-carriers were lower limb (41%) followed by upper
torso (29%) and head/neck (26%) injuries.

> When 2011 and 2012 'overall' tackle-related injuries were combined, the proportion of injuries increased significantly with each quarter of the match (chi-squared linear trend: p<0.05). Approximately 35% of 'overall' tackle-related injuries across all tournaments in 2011 and 2012 occurred during the final quarter of the match. Twenty-four per cent of 'overall' tackle-related injuries occurred in the third quarter followed by the second (23%) and first (17%) guarters. Thirty-three per cent of tackle-related *'time-loss'* injuries across all tournaments in both years occurred during the final quarter of the match followed by the second (24%), third (22%) and first (18%) guarters.

291 Discussion

This study is unique in that it reports exclusively on the nature and rates of tackle-related injuries in elite South African youth rugby union players at a week-long tournament, and it will add to the current literature on tackle injury epidemiology, which is well documented in senior rugby union cohorts.^{9,10,14}

The high proportion of tackle-related injuries observed in this study (Table 2) is consistent with previous rugby union research.⁸⁻¹⁰ The higher proportion of both '*overall*' and '*time-loss*' injuries occurring to the tackler during this study is consistent with some studies conducted in youth rugby union,^{13,20,21} however this finding is also in contrast to other studies which found ball-carriers to be at greater risk.^{12,22} A summary of the evidence suggests that both the tackler and the ball-carrier are proportionally at similar risk of injury during a tackle event.

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304 This study showed a significant decrease in *'time-loss'* injuries between the under-13 and 305 under-18 Craven Week tournaments in 2012. This decrease in injury rates with increasing age is in contrast to previous research.^{3,13,14} There were no significant differences in the 306 307 probability of *'overall'* and *'time-loss'* tackle-related injury between the age categories when 308 both years were combined. However, there was a significantly greater probability of an 309 *overall'* tackle-related injury occurring in 2012 when compared to 2011, although this was 310 not a part of the main analysis. On-going injury surveillance is necessary before these injury 311 trends may be interpreted with confidence.

312

The type of tackle-related injuries did not differ greatly between the age categories. However, there were a higher proportion of skeletal and muscular tackle-related injuries at the under-13 Craven Week tournament. This may perhaps be attributed to the fact that the adolescent skeletal system takes time to adapt to the rapid increase in muscular strength experienced during puberty²⁰ and, as such, not all adolescents are able to tolerate frequent contact situations, potentially placing them at a greater risk. This is an important

319 consideration as these types of contact injuries may affect growth and development.

320

The prevalence of concussion injuries at these tournaments, consistent with previous research in rugby union,^{13,21} remains an area of concern and highlights the need for danger and symptom awareness amongst coaching staff, parents and players³ as many concussion injuries go unreported.²³ In certain instances, symptoms may only manifest at a later stage.

The majority of injuries to the tackler were to the head/neck region while ball-carriers most frequently suffered a lower limb injury. Similar results have been found in senior cohorts,^{9,14} although the current study's findings remain to be confirmed in other youth cohorts. These findings are not unexpected as the nature of the tackle situation in rugby union means that

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the upper extremity of the tackler and lower extremity of the ball-carrier are usually the first
 points of contact.²⁴

> The finding that the frequency of tackle-related injuries increased as playing time progressed within the match is consistent with previous findings in rugby union.^{1,20} This was significant for *'overall'* tackle-related injuries and may be attributed to the effect of fatigue which has been found to play a role in reducing tackle technique proficiency in professional rugby league.²⁵ This may expose players to a greater risk of injury in the tackle situation as playing time in the match progresses.

Multiple risk factors play a role in causing an injury during a tackle event. For example, technique has been found to be an associated risk factor in previous tackle-related injury epidemiology research.^{13,24} This may, in part, explain the higher rates of tackle-related injuries observed in the youngest playing group (under-13 Craven Week). Older, more experienced players have been found to execute a greater proportion of effective tackles, and also miss fewer tackles and incur fewer tackle-breaks.^{14,26} It has also been found that players may only learn proper tackle technique at an older age.²⁷

These findings emphasise the need for coaches to teach correct contact technique from an early age.²⁷ Correct technique is not only necessary to prevent injury but it also increases the likelihood of a successful performance outcome.⁵ Further research into which optimal movement patterns are required during tackle training is essential to help reduce injury rates.²⁸

In addition to technique, it has also been suggested that the increased proportion of injuries associated with the tackle may be due to its open and unpredictable nature in comparison to

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more structured and controlled situations such as the scrum, maul or lineout.^{1,29} This may
warrant research that involves explaining the role of complex, rapidly changing sport
systems³⁰ in tackle-related injury events. Using video analysis in future studies may be one
method with which to achieve this.

The injury rates associated with the tackle may, however, be attenuated by adopting and implementing a multidisciplinary approach.²¹ The following points are examples that could be incorporated into an injury prevention plan; (1) education and coaching of safe and effective tackle techniques e.g. body height and position, head position, and falling technique,^{20,22,24} (2) prompting players to become aware of their immediate surroundings,²⁹ (3) coaching tackle technique in both a fatigued and non-fatigued state,²⁵ and (4) stricter officiating.^{10,22}

Data from this study should not be generalised as the in select cohort of elite youth rugby players at specific wee Comparison of injury rates between youth and senior co formats should be made with caution. There are physica differences between the age-group levels, and previous research has shown that injury rates at tournaments may rates during a league season.³¹ This may be due to the a knock-out competition, fatigue-related factors due to m days, or over-reporting of injuries due to the presence of intervention strategies and injury management protocols differences.2,14,22

A limitation of this study is the short duration and competitive nature of the tournaments. This may result in teams 'hiding' injuries from the tournament doctor to keep that player available

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for the duration of the week. Players may also have been less likely to report injuries on the final day of the tournament as they might have preferred to see their own physician once they had returned home.⁷

> Continued injury surveillance is required in youth rugby union cohorts so that patterns can be identified and better interpreted. A reduced injury risk and a subsequent decrease in injury rates in rugby union should hopefully result in an enhanced player experience, prolonged participation, and increased player numbers.

390 Conclusion

This study provides insight into the nature and rates of tackle-related injuries occurring amongst youth rugby union players in South Africa. The finding that tackle-related injury rates decreased with increasing age is in contrast to previous literature. On-going injury surveillance is required to determine if this finding is repeated in future tournaments. Skeletal and muscular injuries were more prominent in the youngest playing group and the long-term impact of these might need further exploration. Fatigue appears to play a role in the increasing tackle-related injury rates as match time progresses. Further research is required to determine the precise effect of fatigue on tackle technique proficiency and its relation to injury. One can only create an effective injury prevention strategy once the precise risk factors and aetiology of tackle event injuries have been properly determined.

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408	Rugby Safety Programme and Medical Department for commissioning this injury
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411	Contributors
412	NB was granted access to analyse the data, was involved in conceptualising the manuscript,
413	conducted statistical analyses and wrote the initial drafts of the manuscript. NB, JB and SH
414	collected and entered the data. All authors (ML, WV, JB, CR and SH) were involved in
415	conceptualising and editing drafts of the paper, in the order that they appear on the author
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423	
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428	

2 3 4	429	Data sharing statement
5 6	430	Owing to the sensitive nature of the information and appropriate medical ethics, access to a
7 8	431	more detailed aspect of the available dataset will be reviewed upon request and on a
9 10	432	discretionary basis. Sharing of only depersonalised and non-relatable data will be
11 12	433	considered, once permission has been received from WV or CR (can be contacted through
13	131	the corresponding author)
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	2011	2012	2011	2012	2011	2012	2011	2012
Teams	18	18	18	20	26	26	20	20
Matches	36	36	27	30	39	39	30	29
Match time (minutes)	40	40	60	60	70	70	70	70
Exposure time (hours)	720	720	810	900	1365	1365	1050	1015

511

512 Table 2. Proportion of *'overall'* and *'time-loss'* tackle-related injury events occurring in

the four South African Rugby Union (SARU) Youth Week tournaments, 2011 vs. 2012.

	Under-1 W	13 Craven /eek	Under- Khom	16 Grant o Week	Under-18 W	Academy eek	Under-1 W	8 Craven eek
Year	2011	2012	2011	2012	2011	2012	2011	2012
Overall tackle injury %	68	58	54	59	68	65	48	56
Tackler	29	39	19	38	48	37	31	39
Ball-carrier	39	19	35	21	20	28	17	17
TL tackle injury %	73	80	50	52	74	65	37	47
Tackler	27	45	6	48	50	39	20	31
Ball carrier	46	35	11	1	24	26	17	16

514 515 **TL – time-loss**

516 517

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519	Figure legend:
520	
521	Fig.1. (a) A comparison of injury rate (± 95%Cls) of 'overall' tackle-related injuries
522	(including 'time-loss' injuries) at each South African Rugby Union (SARU)
523	tournament in 2011 (white bars) and 2012 (shaded bars), and (b) a comparison of
524	injury rate (± 95%Cls) of tackle-related 'time-loss' injuries between each South
525	African Rugby Union (SARU) tournament in 2011 (white bars) and 2012 (shaded
526	bars). (CW13 – under-13 Craven Week; GK16 – under-16 Grant Khomo Week; AW18
527	under-18 Academy Week; CW18 – under-18 Craven Week)
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TROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cohort studies

Section/Topic	ltem #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6, 9
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5-6
		(b) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-9
		(b) Describe any methods used to examine subgroups and interactions	N/A
		(c) Explain how missing data were addressed	N/A
		(d) If applicable, explain how loss to follow-up was addressed	N/A
		(e) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed	9
		eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5,9
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	9-12
		interval). Make clear which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from	12-16
		similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Fig. (a) A comparison of anatomical location of 'overall' tackle-related injuries in tacklers versus ball-carriers at each South African Rugby Union (SARU) tournament.

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(b) a comparison of anatomical location of tackle-related `time-loss' injuries in tacklers versus ball-carriers at each tournament.



BMJ Open

Tackle-related injury rates and nature of injuries in South African Youth Week tournament rugby union players (under-13 to under-18): an observational cohort study

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Primary Subject Heading :	Sports and exercise medicine
Secondary Subject Heading:	Epidemiology
Keywords:	youth, injury epidemiology, rugby union , tackle

SCHOLARONE[™] Manuscripts

1	Tackle-related injury rates and nature of injuries in South African Youth Week
2	tournament rugby union players (under-13 to under-18): an observational cohort
3	study
4	Nicholas Burger ¹ , Mike I Lambert ¹ , Wayne Viljoen ³ , James C Brown ^{1,2} , Clint
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28 Abstract

29 Objectives

- 30 The tackle situation is most often associated with the high injury rates in rugby union. Tackle
- 31 injury epidemiology in rugby union has previously been focused on senior cohorts but less is
- 32 known about younger cohorts. The aim of this study was to report on the nature and rates of
- 33 tackle-related injuries in South African youth rugby union players representing their
- 34 provinces at national tournaments.

35 Design

36 Observational cohort study.

37 Setting

- Four South African Youth Week tournaments (under-13 Craven Week, under-16 Grant
- 39 Khomo Week, under-18 Academy Week, under-18 Craven Week).

40 Participants

41 Injury data were collected from 3652 youth rugby union players (population at risk) in 2011

42 and 2012.

43 Outcome measures

- 44 Tackle-related injury severity (*'time-loss'* and *'medical attention'*), type and location, injury
- 45 rate per 1000 hours (including 95% confidence intervals). Injury rate ratios were calculated
- 46 and modelled using a Poisson regression. A chi-squared analysis was used to detect linear
- 47 trends between injuries and increasing match quarters.

48 Results

- The 2012 under-13 Craven Week had a significantly greater *'time-loss'* injury rate when
 compared to the 2012 under-18 Academy Week (IRR: 4.43: 95%CI: 2.13-9.21, p<0.05) and
- 50 compared to the 2012 under-18 Academy Week (IRR: 4.43; 95%CI: 2.13-9.21, p<0.05) and
- 51 under-18 Craven Week (IRR: 3.52; 95%CI: 1.54-8.00, p<0.05). The Poisson regression also
- 52 revealed a higher probability of 'overall' ('time-loss' and 'medical attention' combined) and
- 53 *'time-loss'* tackle-related injuries occurring at the under-13 Craven Week. The proportion of

1		
2 3	54	'overall' and 'time-loss' injuries increased significantly with each quarter of the match when
4 5 6	55	all four tournaments were combined (p<0.05).
0 7 8	56	Conclusions
9 10	57	There was a difference in tackle-related injury rate between the under-13 tournament and
11 12	58	the two under-18 tournaments, and tackle-related injury rate was higher in the final quarter of
13 14	59	matches. On-going injury surveillance is required to better interpret these findings. Injury
15 16	60	prevention strategies targeting the tackle may only be effective once rate and nature of the
17 18	61	injuries have been accurately determined.
19 20	62	
21 22	63	Strengths and limitations of this study
23 24	64	This study is novel as it reports specifically on tackle-related injury rates and nature
25 26	65	of injury in high-level South African youth rugby union players.
27 28 20	66	Findings may help identify tackle injury prevention strategies for other youth rugby
29 30 31	67	union players.
32 33	68	 Findings may help prepare medical professionals for injury assessment and
34 35	69	management at youth rugby union tournaments.
36 37	70	 Only injuries reported to the tournament doctor were included in the analysis
38 39	71	Data regarding height and weight for both injured and un-injured players were not
40 41	72	gathered therefore player mismatch could not be analysed as a potential injury risk
42 43	73	factor.
44 45	74	Findings in this study should be generalised with caution as the analysis involved a
46 47	75	specific cohort of players at a week-long tournament in which the match load was
48 49	76	high compared to the recovery period.
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81 Introduction

Rugby union is a team sport played worldwide and characterised by frequent contact and collision situations between players.¹⁻³ The ability to tolerate and contest these situations is a prerequisite for participation and success in the sport.^{2,4,5} The high frequency of collisions places rugby players at higher risk of injury when compared to other non-collision team sports such as soccer and cricket.^{6,7} In particular, the tackle is the contact event most often associated with this high rate of injury.⁸⁻¹⁰

The tackle is defined as "any event where one or more tacklers (player or players making the tackle) attempt to stop or impede the ball-carrier (player carrying the ball) whether or not the ball-carrier was brought to ground".^{5,10} The tackle is an effective way to try and regain possession of the ball, and to prevent the attacking team from gaining field territory and advancing into a point-scoring position.⁵

Tackle-related injury rate has previously been reported for both league (professional English
Premiership⁸ and community level rugby¹¹), and tournament (Rugby World Cup¹²) formats.
The tackle is responsible for a high proportion of upper-body injuries in tacklers, particularly
concussion, head/neck and shoulder injuries, and ball-carriers are more likely to sustain
injuries to the lower-body, particularly thigh muscle and knee injuries.^{8,9,13}

Despite the plethora of tackle injury studies with a focus on senior rugby union players,^{9,10,14} less is known about youth cohorts. Therefore, the aim of this study was to report on the nature and rates of tackle-related injuries occurring at four national youth rugby union tournaments which were hosted by the South African Rugby Union (SARU) in 2011 and 2012. It is noteworthy that this study is unique in comparison to previous research as these tournaments span for one week only and have a high match load compared to recovery period.

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The specific questions of this study, pertaining to tackle-related injuries at youth rugby union tournaments, are as follows; (1) what is the injury rate of the tournaments, (2) do injury rates differ across the tournaments, (3) what are the injury type proportions at the tournaments, (4) do injuries occur at different anatomical locations for ball-carriers and tacklers, and (5) does the rate of injury events increase with match time? The answers to these questions may contribute to the development and implementation of targeted injury prevention and management strategies in youth rugby.

116 Methods

SARU coordinates an injury-surveillance project, via the BokSmart National Rugby Safety Programme,¹⁵ whereby information about all injuries that occur at their Youth Week tournaments are recorded and transcribed into an injury database. Authors were granted access to this database for analysis by SARU and the UCT Human Research Ethics Committee (HREC Ref: 438/2011). All players attending the Youth Week tournaments and their parents/legal guardians signed the SARU Medical and Anti-Doping informed consent form which has a section dedicated to explaining the details of the injury-surveillance project. No player was allowed to participate in the SARU Youth Week Tournaments if this form was not completed and signed by the player and his parent/legal guardian and submitted to the Team Manager. Assent was given by the player at the time of the injury to analyse the recorded information. The Youth Week tournaments are a showcase for South Africa's most talented schoolboy players and include the under-13 Craven Week, under-16 Grant Khomo Week, under-18 Academy Week and under-18 Craven Week tournaments. These tournaments are unique in that they only span the course of one week and may place increased physical demands on players. Participating teams are formed through the selection of the top schoolboy players from within each of the country's 14 provincial rugby unions in addition to one Namibian and one Zimbabwean team. In the case of the two under-18 tournaments, Craven Week involves the best schoolboy players from each union, while

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the Academy Week involves the second tier of players from each union. Each team included
22 players with each player required to start and complete at least one match at the
tournament unless forced off the field of play due to injury.

> The structure of each week varied across the different tournaments (Table 1). 'Match days' (Ms) are defined as days on which all teams played an official tournament match on the same day. For the under-18 Craven Week, when only half the teams played in an alternating fashion for the first four days, one M would span two days to include all the team matches. These days were termed 'tournament match days' (TM) i.e. any day in which official rugby matches were played. This was done for the purpose of comparing the daily load on the tournament medical staff. These terms should be contrasted to 'rest days' (Rs), on which teams were able to partake in other sporting or recreational activities. Exposure was only calculated using Ms (not Rs).

A SARU-appointed doctor was on duty at each tournament to assess every injury that
 occurred. Details about each injury were recorded on an injury collection form that was
 designed based on the Consensus Statement for injury surveillance.¹⁶ Only data pertaining
 to the tackle event were analysed for the purposes of this study.

The injury definition for these tournaments, adapted from the Rugby Union injury Consensus Statement,¹⁶ was stated as 'any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match and required attention from the SARU tournament doctor'.

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'Time-loss' and 'medical attention' tackle-related injuries were reported for this study. A 'time-loss' injury was an injury (based on the aforementioned definition) that resulted in the player being absent for more than one match in a tournament, or more than one day of normal/planned recreational activities during or after the tournament. Injuries were confirmed as *'time-loss'* injuries during the course of the tournament or via telephonic follow-up after the tournament. Weekly phone calls were made to assess the state of the injury until the player returned to practice. 'Medical attention' injuries required treatment from the tournament doctor, but resulted in no loss in recreational, play or practice time. 'Overall' injuries included both 'medical attention' and 'time-loss' injury events. Due to the short duration of each tournament and low absolute injury numbers, *'medical attention'* injuries were included during the analyses in addition to *'time-loss'* injury data to gain insight into the rate and nature of tackle-related injuries.

The '*type*' of injury was categorised as either concussion, spinal cord, broken bone/fracture, joint/ligament/tendon, muscle, bruise, laceration (including skin abrasion), or other by the tournament doctor. If the tournament doctor was unable to diagnose the injury at the time, the injury '*type*' was recorded as '*unsure*'. The '*location*' of the injury was categorised into an anatomical group; head/neck, upper torso, upper limb, lower torso, lower limb, or '*unsure*'.

179 Statistical analysis

Player exposure time was calculated for all 2011 and 2012 tournaments based on the
 current injury collection consensus statement for rugby;¹⁶

Exposure time = $N_M \times P_M \times D_M$

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For this calculation, N_M is the number of matches, P_M is the number of players per match (i.e. 30 players from both sides), and D_M is the duration of the match in hours. This exposure time was used to determine the injury rate and corresponding 95% confidence intervals (95% Cls) for the number of tackle-related injuries per 1000 hours of match play regardless of whether a player was injured more than once.¹⁷

The injury rate ratios (IRR) and corresponding 95% CIs were calculated¹⁸ to determine the difference in injury rates at the different tournaments (each year was analysed separately). The two under-18 tournaments were analysed separately because they are two different levels of play i.e. tier-one (under-18 Craven Week) and tier-two (Academy Week), they have different tournament structures, and therefore have different exposure times (Table 1). The IRR was calculated by dividing the injury rate of one tournament, for example tournament 'A' (numerator – may be representative of any tournament from either year), by its total player exposure time, and then dividing this by the equivalent value for the specific tournament to which it was compared, for example tournament 'B' (denominator – must be representative of another tournament from the same year);

e same year);

$$IRR = \frac{injury \ rate_A / exposure_A}{injury \ rate_B / exposure_B}$$

The standard error (SE) of the log of the IRR was calculated by dividing the total number of tackle injuries of each of the two compared tournaments (*y*) by one, and finding the square root of their sum:

$$SElogIRR = \sqrt{\frac{1}{y_A} + \frac{1}{y_B}}$$
205	Confidence intervals (95%) were then calculated by using the log of the IRR and the SE of
206	the log;
	95% CI = $logIRR \pm 1.96 \times SElogIRR$
207	
208	The IRR was considered significantly greater for the numerator if both 95% CIs were greater
209	than 1.0. Conversely, an IRR was considered significantly lower for the numerator if the both
210	95% CIs were less than 1.0.
211	
211	Significant findings from the IRR analysis were verified using VRP injury statistics software
212	(University of North Carolina, Inium Provention Descerab Center) ¹⁹ The IDD between env
215	(University of North Carolina, injury Frevention Research Center). The IRR between any
214	two tournaments was only considered to be significant if the VRP analysis yielded a p-value
215	of less than 0.05.
216	
217	A Poisson regression was modelled using STATA 11.1 (StataCorp LP, USA) to determine
218	the probability of injury at the tournaments (both years were combined and the under-18
219	Craven Week tournament was used as the reference i.e. denominator).
220	
221	A chi-squared analysis was conducted using GranhPad Prism 5 (version 5.02 for Windows)
221	to determine whether there were any significant linear trands ($n < 0.05$) between the
222	properties of tackle related injuries occurring in each match quarter for all tournaments
223	
224	across both years.
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228 Results

229	Injury surveillance was conducted on 1804 players in 2011 and on 1848 players in 2012
230	(Table 1). Sixty per cent of 'overall' injuries from 2011 and 2012 (n = 260 of 436 injuries)
231	were tackle-related injuries. Sixty-one per cent of 'overall' tackle-related injuries (n = 158 of
232	260 injuries) were to the tackler and 39% (n = 102 of 260 injuries) were to the ball-carrier.
233	Sixty-one per cent of all 'time-loss' injuries from 2011 and 2012 (n = 104 of 171 injuries)
234	were associated with the tackle. Fifty-five per cent of tackle-related 'time-loss' injuries
235	(n = 57 of 104 injuries) were to the tackler and 45% (n = 47 of 104 injuries) were to the ball-
236	carrier. Injury rates were calculated for each tournament in both years (Table 2).
237	
238	(Insert Tables 1 and 2)
239	
240	The Poisson regression model revealed no significant differences in 'overall' and 'time-loss'
241	tackle-related injury rate at the different tournaments when both years were combined.
242	However, there was a higher probability of 'overall' tackle-related injury at the under-13
243	Craven Week when compared to the under-18 Craven Week (IRR: 1.38; 95%CI: 0.96-1.99,
244	p=0.08). Tackle-related 'time-loss' injury also had a higher probability of occurring at the
245	under-13 Craven Week when compared to the under-18 Craven Week (IRR: 1.79;
246	95%Cl: 0.99-3.23, p=0.05).

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There were no significant differences when 'overall' and 'time-loss' tackle-related IRRs were calculated for the 2011 tournaments. However, there was a significantly greater tacklerelated 'time-loss' injury rate at the 2012 under-13 Craven Week tournament when compared to the 2012 under-18 Academy Week (IRR: 4.43; 95%CI: 2.13-9.21, p<0.05) and

2		
3 4	252	under-18 Craven Week (IRR: 3.52; 95%CI: 1.54-8.00, p<0.05). This is consistent with the
5 6 7	253	result from the Poisson regression (see above).
8	254	
10 11	255	(Insert Figures 1A and 1B)
12	256	
14 15	257	The largest proportion of 'overall' tackle-related injuries were joint/ligament/tendon 'type'
16 17	258	injuries (29%, n = 76 of 260 injuries), bruise/contusions (22%), muscle injuries (15%),
18	259	concussions (10%), and lacerations (10%) when all tournaments in 2011 and 2012 were
20 21	260	combined. The greatest proportion of tackle-related 'time-loss' injuries were
22	261	joint/ligament/tendon injuries (34%, n = 35 of 104 injuries), concussions (25%), broken
24 25 26 27	262	bone/fractures (13%), and muscle injuries (12%).
28	263	
29 30	264	When observing anatomical injury locations, 40% of 'overall' tackle-related injuries (n = 63 of
31 32	265	158 injuries) to the tackler across all four tournaments in both years, were head/neck
33 34	266	injuries. Upper torso injuries (24%) were the next most frequent in tacklers followed by lower
35 36	267	limb (17%) and upper limb (16%) injuries. The majority of tackle-related 'time-loss' injuries to
37 38 20	268	tacklers across all four tournaments in both years, were head/neck (44%; n = 25 of 57
40 41	269	injuries) followed by upper torso (30%), lower limb (18%) and upper limb (9%) injuries.
42 43	270	
44 45 46	271	In contrast, the majority of ball-carrier 'overall' tackle-related injuries were lower limb (44%;
40 47 49	272	n = 45 of 102 injuries) followed by head/neck (25%) and upper torso (22%) injuries. The
40 49 50	273	highest proportion of tackle-related 'time-loss' injuries to ball-carriers were lower limb (40%;
50 51 52	274	n = 19 of 47 injuries) followed by upper torso (28%) and head/neck (23%) injuries.
53 54	275	
55 56	276	When 2011 and 2012 'overall' tackle-related injuries were combined, the proportion of
57 58	277	injuries increased significantly with each quarter of the match (chi-squared linear trend:
59 60		11

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p < 0.05). Approximately 35% (n = 91 of 260 injuries) of *'overall'* tackle-related injuries across all tournaments in 2011 and 2012 occurred during the final quarter of the match. Twenty-four per cent of 'overall' tackle-related injuries occurred in the third guarter followed by the second (23%) and first (17%) guarters (1% were unknown). Significantly more tackle-related *time-loss*' injuries occurred in the final quarter of matches when both years were combined (p<0.05). Thirty-seven per cent (n = 38 of 104 injuries) of tackle-related 'time-loss' injuries across all tournaments in both years occurred during the final guarter of the match followed by the second, third and first guarters (all 20%, 3% were unknown).

287 Discussion

This study is unique in that it reports exclusively on the nature and rates of tackle-related injuries in high-level South African youth rugby union players at a week-long tournament, and it will add to the current literature on tackle injury epidemiology, which is well documented in senior rugby union cohorts.^{9,10,14}

The high proportion of tackle-related injuries observed in this study is consistent with previous rugby union research.⁸⁻¹⁰ The higher proportion of both '*overall*' and '*time-loss*' injuries occurring to the tackler during this study is consistent with some studies conducted in youth rugby union,^{20,21} however this finding is also in contrast to other studies which found ball-carriers to be at greater risk.^{13,22,23} Therefore, based on these data, evidence is equivocal as to whether the tackler or ball-carrier is at greatest risk during the tackle situation.

The rate of 'overall' tackle-related injuries at the Youth Week tournaments ranged from 23.8
injuries per 1000 exposure hours (95%CI: 14.5-33.1) at the 2011 under-18 Craven Week
tournament to 50.0 injuries per 1000 exposure hours (95%CI: 33.7-66.3) at the 2012 under-

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13 Craven Week tournament (Table 2). These injury rates are similar to those observed in English Premiership rugby union (33.9 injuries per 1000 exposure hours (30.3-37.9))⁸ and at the Rugby World Cup (tackling 20.2 injuries per 1000 exposure hours (95%CI: 13.9-26.5)¹² and being tackled 18.7 injuries per 1000 exposure hours (95%CI: 12.6-24.7)). However they are much higher than those rates seen in English community-level rugby union (8.4 injuries per 1000 exposure hours (96%CI: 7.8-9.0)).¹¹ This may be due to the higher intensity and level of competition associated with high-level youth and professional senior rugby union in comparison to sub-elite levels of play. It is noteworthy that the English community-level rugby study took place over three seasons in comparison to the compressed tournament structure observed at the SARU Youth Week tournaments and at the Rugby World Cup.

This study showed that there were significantly more *'time-loss'* tackle-related injuries at the 2012 under-13 Craven Week in comparison to the two under-18 tournaments (Academy Week and Craven Week) in 2012. There were no significant differences in the probability of *'overall'* and *'time-loss'* tackle-related injury between the tournaments when both years were combined. However, there was a higher probability of an *'overall'* and *'time-loss'* tacklerelated injury occurring at the under-13 Craven Week. On-going injury surveillance is necessary before these injury trends may be interpreted with confidence.

The type of tackle-related injuries did not differ greatly between the tournaments. The majority of injuries to the tackler were to the head/neck region while ball-carriers most frequently suffered a lower limb injury. Similar results have been found in senior cohorts,^{9,14} although the current study's findings remain to be confirmed in other youth cohorts. These findings are not unexpected as the nature of the tackle situation in rugby union means that the upper extremity of the tackler and lower extremity of the ball-carrier are usually the first points of contact.²⁴ BMJ Open: first published as 10.1136/bmjopen-2014-005556 on 12 August 2014. Downloaded from http://bmjopen.bmj.com/ on May 22, 2025 at Department GEZ-LTA Erasmushogeschool .

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The finding that the frequency of tackle-related injuries increased as playing time progressed within the match is consistent with previous findings in rugby union.^{1,20} This was significant for both 'overall' and 'time-loss' tackle-related injuries and may be attributed to the effect of fatigue which has been found to play a role in reducing tackle technique proficiency in professional rugby league.²⁵ This may expose players to a greater risk of injury in the tackle situation as playing time in the match progresses. Therefore, each coach should make use of their entire squad and ensure that players are substituted and rotated in relation to their levels of fatigue. This is important at the Youth Week tournaments as matches are played on consecutive days and players have less time to recover. Coaches should also condition their players to tackle correctly under fatigued conditions. It is important to train, progress and reinforce tackle safety elements under fatigued and game-like conditions, where decision-making becomes important. By coaching and training these safety elements while fatigued, players will be more likely to execute a safer and more effective tackle under highly pressurised situations in dynamic environments.

Multiple risk factors play a role in causing an injury during a tackle event. For example, technique has been found to be an associated risk factor in previous tackle-related injury epidemiology research.^{14,24} This may, in part, explain the higher rates of tackle-related injuries observed in the youngest playing group (under-13 Craven Week). Older, more experienced players have been found to execute a greater proportion of effective tackles, and also miss fewer tackles and incur fewer tackle-breaks.^{14,26} It has also been found that players may only learn proper tackle technique at an older age.²⁷

These findings emphasise the need for coaches to teach correct contact technique from an early age.²⁷ Correct technique is not only necessary to prevent injury but it also increases the likelihood of a successful performance outcome.⁵ Further research into which optimal

2 3 4	356	movement patterns are required during tackle training is essential to help reduce injury
5 6	357	rates. ²⁸
7 8	358	
9 10	359	In addition to technique, it has also been suggested that the increased proportion of injuries
11 12 12	360	associated with the tackle may be due to its open and unpredictable nature in comparison to
13 14 15	361	more structured and controlled situations such as the scrum, maul or lineout. ^{1,29} This may
16 17	362	warrant research that involves explaining the role of complex, rapidly changing sport
18 19	363	systems ³⁰ in tackle-related injury events. Using video analysis in future studies may be one
20	364	method with which to achieve this.
22 23	365	
24 25	366	The injury rates associated with the tackle may, however, be attenuated by adopting and
20 27	367	implementing a multidisciplinary approach. ²¹ The following points are examples that could be
28 29 20	368	incorporated into an injury prevention plan; (1) education and coaching of safe and effective
30 31 22	369	tackle techniques e.g. body height and position, head position, and falling technique, ^{20,22,24}
33 34	370	(2) prompting players to become aware of their immediate surroundings, ²⁹ (3) coaching
35 36	371	tackle technique in both a fatigued and non-fatigued state, ²⁵ and (4) stricter officiating. ^{10,22}
37 38 20	372	
40 41	373	Data from this study should be generalised with caution as the injury surveillance was
42 43	374	conducted on a select cohort of high-level youth rugby players at specific week-long
44	375	tournaments in South Africa. Comparison of injury rates between youth and senior cohorts,
46 47	376	and tournament and league formats should also be made with caution. There are physical
48 49	377	growth and developmental differences between the age-group levels, and previous team
50 51	378	sport injury epidemiological research has shown that injury rates at tournaments may be
52 53	379	inflated in comparison to injury rates during a league season. ³¹ This may be due to the
54 55	380	higher intensity of play involved with a knock-out competition, fatigue-related factors due to
56 57 58	381	matches being played on consecutive days, or over-reporting of injuries due to the presence
59		

of numerous medical personnel. Injury intervention strategies and injury management

protocols should be sensitive to these differences.^{2,14,22}

 A limitation of this study is the short duration and competitive nature of the tournaments. This may result in teams 'hiding' injuries from the tournament doctor to keep that player available for the duration of the week. Players may also have been less likely to report injuries on the final day of the tournament as they might have preferred to see their own physician once they had returned home.7 Continued injury surveillance is required in youth rugby union cohorts so that patterns can be identified and better interpreted. A reduced injury risk and a subsequent decrease in injury rates in rugby union should hopefully result in an enhanced player experience, prolonged participation, and increased player numbers. Conclusion This study provides insight into the nature and rates of tackle-related injuries occurring amongst youth rugby union players in South Africa. Tackle-related injury rate was highest at the 2012 under-13 Craven Week tournament, and a there was a higher probability for a tackle-related injury to occur at the under-13 Craven Week when both years were combined. On-going injury surveillance is required to determine if this finding is repeated in future tournaments. Tackle-related injury type did not differ across the tournaments for both overall' and 'time-loss' injuries. Fatigue appears to play a role in the increasing tackle-related injury rates as match time progresses. Further research is required to determine the precise effect of fatigue on tackle technique proficiency and its relation to injury. This evidence, along with information detailing the precise risk factors and aetiology of tackle event injuries, may help guide the formation of effective injury prevention strategies.

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423	The authors have no conflict of interest to declare.
424	Ethics approval

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- 429 Owing to the sensitive nature of the information and appropriate medical ethics, access to a
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2								
3	431	discretionary basis. Sharing of only depersonalised and non-relatable data will be						
5	432	considered, once permission has been received from WV or CR (can be contacted via email						
6 7 8	433	through the corresponding author - nicholas.burger@uct.ac.za).						
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	Under-13 Craven Week		Under-16 Grant Khomo Week		Under-18 Academy Week		Under-18 Craven Week		
Year Teams	2011 18	2012 18	2011 18	2012 20	2011 26	2012 26	2011 20	2012 20	
Matches	36	36	27	30	39	39	30	29	
Match time (minutes)	40	40	60	60	70	70	70	70	
Tournament	M, M, R	, M, M	M,M,	R,M	M,M	,R,M	TM, TM,	TM, TM,	
structure							R, M		
Exposure time (hours)	720	720	810	900	1365	1365	1050	1015	
 516 517 Table 2. 'Ove 518 African Ruge 	e <i>rall'</i> and by Union	ʻtime-loss (SARU) Y	s' tackle-re outh Week	lated inju	ry rates oc	curring in t vs. 2012.	he four Sc	outh	
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516 517 Table 2. 'Ove 518 African Rugi	e <i>rall'</i> and by Union Unde 2011	ftime-loss (SARU) Y er-13 Crave Week 2012 26	e' tackle-re outh Week en Und Kh 2 2011	lated inju tourname er-16 Gra omo Wee 1 201	ry rates oc ents, 2011 nt Unde k 2 201	curring in t vs. 2012. er-18 Acade Week <u>1 201</u>	he four Sc emy Unc 2 20'	outh Jer-18 Cra Week 11 20	
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516 517 Table 2. 'Ove 518 African Rug <u>Year</u> Overall tackle injuries (n Overall injury rat 95% Cl	erall' and by Union Unde 2011 1) 21 te 29.2 16.8 41.6	<i>'time-loss</i> (SARU) Y er-13 Crave <u>Week</u> 2012 36 50.0 - 33.7 66.3	s' tackle-re outh Week en Und 2011 20 24.7 - 13.9 35.5	lated inju tourname er-16 Gra omo Wee <u>1 201</u> 33 7 36. ² - 24.2 5 49.1	ry rates oc ents, 2011 nt Unde <u>k</u> 2 201 7 34.4 2 24.6 2 44.3	curring in t vs. 2012. er-18 Acade <u>Week</u> 1 201 44 4 32.3 5 - 22.7 3 41.4	he four Sc emy Unc 2 20 2 23 7 - 14.3 8 33	buth der-18 Cra <u>Week</u> <u>11 20</u> 5 3 .8 33 5 - 22 .1 44	
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521	Figure legend:
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523	Fig.1. (a) A comparison of injury rate (± 95%CIs) of 'overall' tackle-related injuries (including
524	'time-loss' injuries) at each South African Rugby Union (SARU) tournament in 2011 (white
525	bars) and 2012 (shaded bars), and (b) a comparison of injury rate (\pm 95%Cls) of tackle-
526	related 'time-loss' injuries between each South African Rugby Union (SARU) tournament in
527	2011 (white bars) and 2012 (shaded bars). (CW13 – under-13 Craven Week; GK16 –
528	under-16 Grant Khomo Week; AW18 – under-18 Academy Week; CW18 – under-18
529	Craven Week)
530	Fig.1. (b) A comparison of injury rate (± 95%Cls) of tackle-related 'time-loss' injuries
531	between each South African Rugby Union (SARU) tournament in 2011 (white bars) and
532	2012 (shaded bars). (CW13 – under-13 Craven Week; GK16 – under-16 Grant Khomo
533	Week; AW18 – under-18 Academy Week; CW18 – under-18 Craven Week)
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1	Tackle-related injury rates and nature of injuries in <u>South African national</u> Youth Week
2	tournament rugby union players tournaments in South Africa (under-13 to under-18):
3	an observational cohort study
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8	20	
9	29	ADSTRACT
10	30	Objectives
11		
12	31	The tackle situation is most often associated with the high injury rates in rugby union. Tackle
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15	32	injury epidemiology in rugby union has previously been focused on senior conorts but less is
16	33	known about younger cohorts. The aim of this study was to report on the nature and rates of
1/ 18	34	tackle-related injuries in South African youth rugby union players representing their
19	54	tackie-related injuries in oodan Ancan youan rugby union players representing their
20	35	provinces at national tournaments.in elite South African youth rugby union players.
21		
22	36	
23 24	37	Design
25		
26	38	Observational cohort study.
27	39	
28 29		
30	40	Setting
31	41	Four South African Youth Week tournaments (under-13 Craven Week, under-16 Grant
32	12	Khomo Week under 18 academy Academy Week under 18 Craven Week)
33 34	42	Kilonio week, under to deddenny <u>Aeddenny</u> week, under to oraven week).
35	13	
36	73	
37	44	Participants
38	45	Injury data were collected from 3652 youth rugby union players (population at risk) in 2011
40		
41	46	and 2012.
42	47	
43 11	40	
45	48	
46	49	Tackle-related injury severity (<u>(time-loss' and timedical attention')</u> , type and location, injury
47	50	rate per 1000 hours (including 95% confidence intervals). Injury rate ratios were calculated
48 ⊿0		
	51	and modelled using a Poisson regression. A chi-squared analysis was used to detect linear
51	52	trends between injuries and increasing match quarters.
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6 7	54	
8 9	55	Results
10	56	The 2012 under-13 Craven Week had a significantly greater 'time-loss' injury rate when
12	57	compared to the 2012 under-18 Academy Week (IRR: 4.43; 95%CI: 2.13-9.21, p<0.05) and
13 14	58	under-18 Craven Week (IRR: 3.52; 95%CI: 1.54-8.00, p<0.05). There was The Poisson
15 16	59	regression also revealed a higher probability of 'overall' (<u>(time-loss' and (medical attention</u>) Formatted: Font: Italic
17 18	60	<u>combined</u>) and <i>'time-loss'</i> tackle-related injuries occurring at the under-13 Craven Week.
19 20	61	The under-13 Craven Week had a significantly greater 'time-loss' injury rate when compared
21	62	t o the 2012 under 18 Craven Week (IRR: 3.52; 95%CI: 1.54-8.00, p<0.05). The under 13
22 23	63	Graven Week also had the greatest proportion of broken bone/factures and muscular injuries
24 25	64	for both 'overall' (12% and 23%) and 'time loss' injuries (28% and 22%). The proportion of
26 27	65	overall' and <u>'time-loss'</u> injuries increased significantly with each quarter of the match when
28	66	all four tournaments were combined (p<0.05).
30	67	
31 32	68	Conclusions
33 34	69	Age-There was a difference in tackle-related injury rate between the under-13 tournament
35 36	70	and the two under-18 tournaments and tackle-related injury rate increased as match time
37	71	progressedmatch-related fatigue may affect the rates and nature of tackle-related injuries in
38 39	72	youth rugby union . On-going injury surveillance is required to <u>better</u> interpret these findings.
40 41	73	Injury prevention strategies targeting the tackle may only be effective once rate and nature of
42 43	74	the injuries have been <u>accurately</u> determined.
44 45	75	
46	76	Key words: youth; injury epidemiology; rugby union; tackle.
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82	Strengths and limitations of this study
83	This study is novel as it reports specifically on tackle-related injury rates and nature
84	of injury in elite-high-level South African youth rugby union players.
85	 Findings may help identify tackle injury prevention strategies for other youth rugby
86	union players.
87	 Findings may help prepare medical professionals for injury assessment and
88	management at youth rugby union tournaments.
89	 Only injuries reported to the tournament doctor were included in the analysis
90	Data regarding height and weight for both injured and un-injured players were not
91	gathered therefore player mismatch could not be analysed as a potential injury risk
92	factor.
93	• Findings in this study should not be generalised with caution as the analysis involved
94	a specific cohort of players at a week-long tournament in which the match load was
95	high compared to the recovery period.
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9 10	110	Introduction
11 12	111	Rugby union is a team sport played worldwide and characterised by frequent contact and
13	112	collision situations between players ¹⁻³ The ability to tolerate and contest these situations is a
14 15	112	prerequisite for participation and success in the sport ^{2,4,5} The high frequency of contact
16 17	113	situationscelligions places rugby players at higher risk of injury when compared to other pon
18	114	situations compared to other home
19 20	115	<u>collision</u> team sports such as soccer and cricket. ³⁵ In particular, the tackle is the contact
21 22	116	event most often associated with this high rate of injury. ^{or 10}
23	117	
24 25	118	The tackle is defined as "any event where one or more tacklers (player or players making the
26 27	119	tackle) attempt to stop or impede the ball-carrier (player carrying the ball) whether or not the
28	120	ball-carrier was brought to ground". ^{5,10} The tackle is an effective way to try and regain
29 30	121	possession of the ball, and to prevent the attacking team from gaining field territory and
30 31 32	122	advancing into a point-scoring position. ⁵
33	123	
34 35	124	Tackle-related injury rate has previously been reported for both league and tournament
36 37	125	formats in (professional English Premiership-rugby ⁸ and community level rugby ¹¹), and at the
38 39	126	tournament-(Rugby World Cup^{12}) ¹¹ respectively formats. The tackle is responsible for a high
40 41	127	proportion of upper-body injuries in tacklers, particularly concussion, head/neck and
42	128	shoulder injuries, and ball-carriers are more likely to sustain injuries to the lower-body,
43 44	129	particularly thigh muscle and knee injuries. ^{8,9,42} _13
45 46	130	
47 48	131	Despite the plethora of tackle injury studies with a focus on senior rugby union players, ^{9,10,14}
49	132	¹⁵ less is known about youth cohorts. Therefore, the aim of this study was to report on the
50 51	133	nature and rates of tackle-related injuries occurring at four elite-national youth rugby union
52 53	134	tournaments which were hosted by the South African Rugby Union (SARU) in 2011 and
54 55	135	2012. It is noteworthy that this study is unique in comparison to previous research as these
56 57 58		5

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tournaments span for one week only and have a high match load compared to recovery period.

The specific questions of this study, pertaining to tackle-related injuries at youth rugby union tournaments, are as follows; (1) what is the injury rate of the tournaments, (42) are do injury rates comparable differ across the age categories tournaments (13 to 18 years), (23) do what are the injury type proportions at the tournaments differ across the age categories, (34) do injuries occur at different anatomical locations for ball-carriers and tacklers, and (45) does the rate of injury events increase with match time? The answers to these questions may contribute to the development and implementation of targeted injury prevention and management strategies in youth rugby.

148 Methods

SARU coordinates an injury-surveillance project, via the BokSmart National Rugby Safety Programme,¹⁵⁻¹⁶ whereby information about all injuries that occur at their Youth Week tournaments are recorded and transcribed into an injury database. Authors were granted access to this database for analysis by SARU and the UCT Human Research Ethics Committee (HREC Ref: 438/2011). All players attending the Youth Week tournaments and their parents/legal guardians signed the SARU Medical and Anti-Doping informed consent form which has a section dedicated to explaining the details of the injury-surveillance project. When a player was injured, informed consent to analyse the recorded information was once again-confirmed either by the player or by the player's parent or guardian if present at the time of the injury assessment. At this point, the player or parent/guardian had the option to deny access to their personal information or details regarding the injury event. The Youth Week tournaments are a showcase for South Africa's most talented schoolboy players and include the under-13 Craven Week, under-16 Grant Khomo Week, under-18 Academy Week

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and under-18 Craven Week tournaments. These tournaments are unique in that they only span the course of one week and thus may place increased physical demands on players. Participating teams are formed through the selection of the top schoolboy players from within each of the country's 14 provincial rugby unions in addition to one Namibian and one Zimbabwean team. In the case of the two under-18 tournaments, Craven Week involves the best schoolboy players from each union, while the Academy Week involves the second tier of players from each union. Each team included 22 players with each player required to start and complete at least one match at the tournament unless forced off the field of play due to injury.

The structure of each week varied across the different tournaments (Table 1). 'Match days' (Ms) are defined as days on which all teams played an official tournament match on the same day. For the under-18 Craven Week, when only half the teams played in an alternating fashion for the first four days, one M would span two days to include all the team matches. These days were termed 'tournament match days' (TM) i.e. any day in which official rugby matches were played. This was done for the purpose of comparing the daily load on the tournament medical staff. These terms should be contrasted to 'rest days' (Rs), on which teams were able to partake in other sporting or recreational activities. Exposure was only calculated using Ms (not Rs).

A SARU-appointed doctor was on duty at each tournament to assess every injury that occurred. Details about each injury were recorded on an injury collection form that was designed based on the Consensus Statement for injury surveillance.¹⁶⁻¹⁷Only data pertaining to the tackle event were analysed for the purposes of this study.

The injury definition for these tournaments, adapted from the Rugby Union injury Consensus Statement,⁴⁶-¹⁷ was stated as 'any physical complaint, which was caused by a transfer of energy that exceeded the body's ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match and required attention from the SARU tournament doctor'.

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'Time-loss' and 'medical attention' tackle-related injuries were reported for this study. A 'time-loss' injury was an injury (based on the aforementioned definition) that resulted in the player being absent for more than one match in a tournament, or more than one day of normal/planned recreational activities during or after the tournament. Injuries were confirmed as 'time-loss' injuries during the course of the tournament or via telephonic follow-up after the tournament. Weekly phone calls were made to assess the state of the injury until the player returned to practice. 'Medical attention' injuries required treatment from the tournament doctor, but resulted in no loss in recreational, play or practice time. 'Overall' injuries included both 'medical attention' and 'time-loss' injury events. Due to the short duration of each tournament and low absolute injury numbers, 'medical attention' injuries were included during the analyses, as important information may have been overlooked if only in addition to 'time-loss' injury data were considered.⁷ to gain insight into the rate and nature of tackle-related injuries.

The '*type*' of injury was categorised as either concussion, spinal cord, broken bone/fracture, joint/ligament/tendon, muscle, bruise, laceration (including skin abrasion), or other by the tournament doctor. If the tournament doctor was unable to diagnose the injury at the time, the injury '*type*' was recorded as '*unsure*'. The '*location*' of the injury was categorised into an anatomical group; head/neck, upper torso, upper limb, lower torso, lower limb, or '*unsure*'.

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6 7	236	tournament 'B' (denominator - must be representative of another tournament from the same
8 9	237	<u>year</u>);
10 11 12	238	
13 14 15 16		$IRR = \frac{injury rate_A / exposure_A}{injury rate_B / exposure_B}$
17	239	The standard error (SE) of the log of the IRR was calculated by dividing the total number of
18 19	240	tackle injuries of each of the two compared tournaments (y) by one, and finding the square
20 21	241	root of their sum;
22 23 24	242	
25 26 27 28		$SElogIRR = \sqrt{\frac{1}{y_A} + \frac{1}{y_B}}$
29 30 31	243	
32 33	244	Confidence intervals (95%) were then calculated by using the log of the IRR and the SE of
34	245	the log;
35 36 37	246	
38 39 40		95% CI = $logIRR \pm 1.96 \times SElogIRR$
41 42	247	
43 44 45	248	The IRR was considered significantly greater for the numerator if both 95% CIs were greater
46	249	than 1.0. Conversely, an IRR was considered significantly lower for the numerator if the both
47 48 49	250	95% Cls were less than 1.0.
50	251	
51 52	252	Significant findings from the IRR analysis were verified using VRP injury statistics software
53 54 55	253	(University of North Carolina, Injury Prevention Research Center). ⁴⁹ -20 The IRR between any
56 57 58 59 60		10

254	two tournaments was only considered to be significant if the VRP analysis yielded a p-value	
255	of less than 0.05.	
256		
257	A Poisson regression was modelled using STATA 11.1 (StataCorp LP, USA) to determine	
258	the probability of injury across the age categoriesat the tournaments (both years were	
259	combined and the- under-18 Craven Week tournament was used as the reference i.e.	
260	denominator). The year of the each tournament was factored into the model (2011 was used	
261	as the reference i.e. denominator) even though this was not part of the main analysis.	
262		
263	A chi-squared analysis was conducted using GraphPad Prism 5 (version 5.02 for Windows)	
264	to determine whether there were any significant linear trends (p<0.05) between the	
265	proportion of tackle-related injuries occurring in each match quarter for all tournaments	
266	across both years.	
267		
268	Results	
• • •		
269	Injury surveillance was conducted on 1804 players in 2011 and on 1848 players in 2012	
270	(Table 1). Sixty per cent of ' <i>overall</i> ' injuries (Table 2) from 2011 and 2012 (n = 263-260 of	
271	440-436 injuries) were tackle-related injuries. Sixty-one per cent of 'overall' tackle-related	
272	injuries (n = 158 of 260 injuries) were to the tackler and 39% (n = 102 of 260 injuries) were to	
273	the ball-carrier. Fifty-nineSixty-one per cent of all 'time-loss' injuries (Table 2) from 2011 and	
274	2012 (n = 104 of 176-<u>171</u> injuries) were associated with the tackle. Sixty Fifty-five per cent of	
275	tackle-related 'time-loss' injuries <u>(n = 57 of 104 injuries)</u> were to the tackler and 40 <u>45</u> %	
276	(n = 47 of 104 injuries) were to the ball-carrier. Injury rates were calculated for each	
277	tournament in both years (Table 2).	
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1	The 'overall' tackle related injury rates at the 2011 tournaments were 29.2 injuries per 1000
	exposure hours (95%CI: 16.8-41.6) at under 13 Craven Week, 24.7 injuries per 1000
	exposure hours (95%CI: 13.9-35.5) at under-16 Grant Khomo Week, 34.4 injuries per 1000
	exposure hours (95%CI: 24.6-44.3) at under-18 Academy Week, and 23.8 injuries per 1000
	exposure hours (95%CI: 14.5 33.1) at under 18 Craven Week (Figure 1A). The 'overall'
	tackle related injury rates at the 2012 tournaments were 50.0 injuries per 1000 exposure
	hours (95%CI: 33.7-66.3) at under 13 Craven Week, 36.7 injuries per 1000 exposure hours
	(95%CI: 24.2 49.2) at under 16 Grant Khomo Week, 34.4 injuries per 1000 exposure hours
	(95%CI: 24.6-44.3) at under 18 Academy Week, and 33.5 injuries per 1000 exposure hours
	(95%CI: 22.2-44.8) at under-18 Craven Week.

Analysis of tackle-related '*time-loss*' injury rates of the 2011 tournaments showed 11.1 injuries per 1000 exposure hours (95%CI: 3.4-18.8) at under 13 Craven Week, 9.9 injuries per 1000 exposure hours (95%CI: 3.0-16.7) at under-16 Grant Khomo Week, 18.3 injuries per 1000 exposure hours (95%CI: 11.1-25.5) at under 18 Academy Week, and 10.5 injuries per 1000 exposure hours (95%CI: 4.3-16.7) at under 18 Craven Week (Figure 1B). The tackle-related '*time-loss*' injury rates of the 2012 tournaments showed 22.2 injuries per 1000 exposure hours (95%CI: 11.3-33.1) at under 13 Craven Week, 13.3 injuries per 1000 exposure hours (95%CI: 5.8-20.9) at under 16 Grant Khomo Week, 11.0 injuries per 1000 exposure hours (95%CI: 5.4-16.6) at under-18 Academy Week, and 8.9 injuries per 1000 exposure hours (95%CI: 3.1-14.7) at under 18 Craven Week.

The Poisson regression model revealed no significant differences in *'overall'* and *'time-loss'* tackle-related injury rate across the age categories at the different tournaments when both

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7	305	years were combined. However, there was a higher probability of 'overall' tackle-related
8 9	306	injury at the under-13 Craven Week when compared to the under-18 Craven Week (IRR:
10	307	1.38; 95%CI: 0.96-1.99, p=0.08). Tackle-related <i>'time-loss'</i> injury also had a higher
12	308	probability of occurring at the under-13 Craven Week when compared to the under-18
13 14	309	Craven Week (IRR: 1.72<u>1.79</u>; 95%CI: <u>0.950.99</u>-<u>3.12<u>3.23</u>, p=0.07<u>0.05</u>). There was a</u>
15 16	310	significantly higher chance of incurring an 'overall' tackle related injury in 2012 when
17	311	compared to 2011 (IRR: 1.31; 95%CI: 1.03-1.67, p<0.05).
19	212	
20 21	312	
22	313	There were no significant differences when 'overall' and 'time-loss' tackle-related IRRs were
23 24	314	calculated for the 2011 tournaments. However, there was a significantly greater tackle-
25 26	315	related 'time-loss' injury rate at the 2012 under-13 Craven Week tournament when
27 28	316	compared to the 2012 under-18 Academy Week (IRR: 4.43; 95%CI: 2.13-9.21, p<0.05) and
29	317	under-18 Craven Week (IRR: 3.52; 95%CI: 1.54-8.00, p<0.05). This is consistent with the
30 31	318	result from the Poisson regression (see above).
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35 36	320	(Insert Figures 1A and 1B)
37 38	321	
39	322	The largest proportion of 'overall' tackle-related injuries were joint/ligament/tendon 'type'
40 41	323	injuries (29%, n = 76 of 260 injuries), bruise/contusions (221%), muscle injuries (15%).
42 43	324	concussions (1110%) and lacerations (10%) when all tournaments in 2011 and 2012 were
44	325	combined. The greatest proportion of tackle-related ' <i>time-loss</i> ' injuries were
45 46	326	ioint/ligament/tendon injuries (3234% $n = 35$ of 104 injuries) concussions (2725%) muscle
47 48	227	injuries (12%) and broken hope/fractures (1213%) and muscle injuries (12%). The under 13
49 50	220	$\frac{1}{10}$
51	220	craven week tournament had the greatest proportion or proven point/additions and muscle-
52 53	329	and 20% respectively) when 2011 and 2012 were same in a
54 55	330	and 22% respectively) when 2011 and 2012 were combined.
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When observing anatomical injury locations, 40% of 'overall' tackle-related injuries (n = 63 of 158 injuries) to the tackler across all four tournaments in both years, were head/neck injuries. Upper torso injuries (24%) were the next most frequent in tacklers followed by lower limb (17%) and upper limb (16%) injuries. The majority of tackle-related 'time-loss' injuries to tacklers across all four tournaments in both years, were head/neck (4544%; n = 25 of 57 injuries) followed by upper torso (2630%), lower limb (1918%) and upper limb (109%) injuries.

In contrast, the majority of ball-carrier 'overall' tackle-related injuries were lower limb (44%; n = 45 of 102 injuries) followed by head/neck (2625%) and upper torso (22%) injuries. The highest proportion of tackle-related 'time-loss' injuries to ball-carriers were lower limb (4140%); n = 19 of 47 injuries) followed by upper torso (2928%) and head/neck (2623%)injuries.

When 2011 and 2012 'overall' tackle-related injuries were combined, the proportion of 846 847 injuries increased significantly with each quarter of the match (chi-squared linear trend: 48 p<0.05). Approximately 35% (n = 91 of 260 injuries) of 'overall' tackle-related injuries across 349 all tournaments in 2011 and 2012 occurred during the final quarter of the match. Twenty-four 850 per cent of 'overall' tackle-related injuries occurred in the third guarter followed by the second (23%) and first (17%) quarters (1% were unknown). Significantly more tackle-related 351 352 time-loss' injuries occurred in the final quarter of matches when both years were combined 353 (p<0.05). Thirty-three-seven per cent (n = 38 of 104 injuries) of tackle-related 'time-loss' injuries across all tournaments in both years occurred during the final guarter of the match 354 355 followed by the second (24%), third (22%) and first (18%) quarters (all 20%, 3% were 856 unknown).

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358	Discussion	
250	This shudu is unique in that it was and such as the patient and wates of tables what	
359	This study is unique in that it reports exclusively on the nature and rates of tackie-related	
360	injuries in clitte-<u>high-level</u> South African youth rugby union players at a week-long	
361	tournament, and it will add to the current literature on tackle injury epidemiology, which is	
362	well documented in senior rugby union cohorts. ^{9,10,1415}	
363		
364	The high proportion of tackle-related injuries observed in this study (Table 2) is consistent	
365	with previous rugby union research. ⁸⁻¹⁰ The higher proportion of both 'overall' and 'time-loss'	
366	injuries occurring to the tackler during this study is consistent with some studies conducted	
367	in youth rugby union, ^{1314,2021,21} , ²² however this finding is also in contrast to other studies	
368	which found ball-carriers to be at greater risk. ^{4213,22} -23,24 A summary of the evidence suggests	
369	that both the tackler and the ball carrier are proportionally at similar risk of injury during a	
370	tackle event. Therefore, based on these data, evidence is equivocal as to whether the	
371	tackler or ball-carrier is at greatest risk during the tackle situation.	
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373	The rate of <i>coverall'</i> tackle-related injuries at the Youth Week tournaments ranged from 23.8	Formatted: Font: Italic
374	injuries per 1000 exposure hours (95%CI: 14.5-33.1) at the 2011 under-18 Craven Week	
375	tournament to 50.0 injuries per 1000 exposure hours (95%CI: 33.7-66.3) at the 2012 under-	
376	13 Craven Week tournament (Table 2). These injury rates are similar to those observed in	
377	English Premiership rugby union (33.9 injuries per 1000 exposure hours (30.3-37.9)) ⁸ and at	
378	the Rugby World Cup (tackling 20.2 injuries per 1000 exposure hours (95%CI: 13.9-26.5) ¹²	
379	and being tackled 18.7 injuries per 1000 exposure hours (95%CI: 12.6-24.7)). However they	
380	are much higher than those rates seen in English community-level rugby union (8.4 injuries	
381	per 1000 exposure hours (96%CI: 7.8-9.0)). ¹¹ This may be due to the higher intensity and	
382	level of competition associated with high-level youth and professional senior rugby union in	
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383	comparison to sub-elite levels of play. It is noteworthy that the English community-level	
384	rugby study took place over three seasons in comparison to the compressed tournament	
385	structure observed at the SARU Youth Week tournaments and at the Rugby World Cup.	
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387	This study showed a- <u>that there were</u> significantly decrease more in-'time-loss' tackle-related	
388	injuries between at the 2012 under 13 Craven Week and in comparison to the two under 18	
389	tournaments (Academy Week and Craven Week) tournaments in 2012. This decrease in	
390	injury rates with increasing age is in contrast to previous research. ^{3,13,14} -There were no	
391	significant differences in the probability of 'overall' and 'time-loss' tackle-related injury	
392	between the age categoriestournaments when both years were combined. However, there	
393	was a significantly greater probability of an 'overall' tackle-related injury occurring in 2012	
394	when compared to 2011, although this was not a part of the main analysis. On-going injury	
395	surveillance is necessary before these injury trends may be interpreted with confidence.	
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397	The type of tackle-related injuries did not differ greatly between the age	
398	categoriestournaments. However, there were a higher proportion of skeletal and muscular	
399	tackle-related injuries at the under-13 Craven Week tournament. This may perhaps be	
400	attributed to the fact that the adolescent skeletal system takes time to adapt to the rapid	
401	increase in muscular strength experienced during puberty ²⁰ and, as such, not all adolescents	
402	are able to tolerate frequent contact situations, potentially placing them at a greater risk. This	
403	is an important consideration as these types of contact injuries may affect growth and	
404	development.	
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406	The prevalence of concussion injuries at these tournaments, consistent with previous	
407	research in rugby union, ^{13,21} -remains an area of concern and highlights the need for danger	
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and symptom awareness amongst coaching staff, parents and players³ as many concussion injuries go unreported.²³ In certain instances, symptoms may only manifest at a later stage. The majority of injuries to the tackler were to the head/neck region while ball-carriers most frequently suffered a lower limb injury. Similar results have been found in senior cohorts,^{9,14} ¹⁵ although the current study's findings remain to be confirmed in other youth cohorts. These findings are not unexpected as the nature of the tackle situation in rugby union means that the upper extremity of the tackler and lower extremity of the ball-carrier are usually the first points of contact.²⁴²⁵

The finding that the frequency of tackle-related injuries increased as playing time progressed within the match is consistent with previous findings in rugby union.^{1,20}²¹ This was significant for both 'overall' and ,'time-loss' tackle-related injuries and may be attributed to the effect of fatigue which has been found to play a role in reducing tackle technique proficiency in professional rugby league.^{25,26} This may expose players to a greater risk of injury in the tackle situation as playing time in the match progresses. Therefore, each coach should make use of their entire squad and ensure that players are substituted and rotated in relation to their levels of fatigue. This is important at the Youth Week tournaments as matches are played on consecutive days and players have less time to recover. Coaches should also condition their players to tackle correctly under fatigued conditions. It is important to train, progress and reinforce tackle safety elements under fatigued and game-like conditions. where decision-making becomes important. By coaching and training these safety elements while fatigued, players will be more likely to execute a safer and more effective tackle under highly pressurised situations in dynamic environments.

432 Multiple risk factors play a role in causing an injury during a tackle event. For example,

technique has been found to be an associated risk factor in previous tackle-related injury

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epidemiology research.^{4314,24}_²⁵This may, in part, explain the higher rates of tackle-related injuries observed in the youngest playing group (under-13 Craven Week). Older, more experienced players have been found to execute a greater proportion of effective tackles, and also miss fewer tackles and incur fewer tackle-breaks.^{4415,26}_²⁷ It has also been found that players may only learn proper tackle technique at an older age.²⁷²⁸

These findings emphasise the need for coaches to teach correct contact technique from an early age.^{27_28} Correct technique is not only necessary to prevent injury but it also increases the likelihood of a successful performance outcome.⁵ Further research into which optimal movement patterns are required during tackle training is essential to help reduce injury rates.^{28_29}

In addition to technique, it has also been suggested that the increased proportion of injuries associated with the tackle may be due to its open and unpredictable nature in comparison to more structured and controlled situations such as the scrum, maul or lineout.^{1,29},³⁰ This may warrant research that involves explaining the role of complex, rapidly changing sport systems³⁰-systems³¹ in tackle-related injury events. Using video analysis in future studies may be one method with which to achieve this.

The injury rates associated with the tackle may, however, be attenuated by adopting and implementing a multidisciplinary approach.²⁴-²²_The following points are examples that could be incorporated into an injury prevention plan; (1) education and coaching of safe and effective tackle techniques e.g. body height and position, head position, and falling technique, ^{2021,2223,24}-²⁵_(2) prompting players to become aware of their immediate surroundings, ²⁹-³⁰_(3) coaching tackle technique in both a fatigued and non-fatigued state, ²⁶/₂₆ and (4) stricter officiating.^{10,2223}

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9 10 11 12	461	Data from this study should not be generalised with caution as the injury surveillance was	
	462	conducted on a select cohort of elite-high-level youth rugby players at specific week-long	
	463	tournaments in South Africa. Comparison of injury rates between youth and senior cohorts,	
13 14	464	and tournament and league formats should also be made with caution. There are physical	
15 16	465	growth and developmental differences between the age-group levels, and previous team	
17	466	sport injury epidemiological research has shown that injury rates at tournaments may be	
18	467	inflated in comparison to injury rates during a league season. ³⁴ -32 This may be due to the	
20 21	468	higher intensity of play involved with a knock-out competition, fatigue-related factors due to	
22 23	469	matches being played on consecutive days, or over-reporting of injuries due to the presence	
24	470	of numerous medical personnel. Injury intervention strategies and injury management	
25 26 27	471	protocols should be sensitive to these differences. ^{2,1415,22,23}	
28	472		
29 30	472	A limitation of this study is the short duration and compatitive nature of the tournaments. This	
31 32	475	A limitation of this study is the short duration and competitive nature of the tournaments. This may result in teams (hiding' injuries from the tournament destar to keep that player available	
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34 35	475	for the duration of the week. Players may also have been less likely to report injuries on the	
36	476	final day of the tournament as they might have preferred to see their own physician once	
37	477	they had returned home. ⁷	
39 40	478		
41 42	479	Continued injury surveillance is required in youth rugby union cohorts so that patterns can be	
43 44	480	identified and better interpreted. A reduced injury risk and a subsequent decrease in injury	
45	481	rates in rugby union should hopefully result in an enhanced player experience, prolonged	
40 47 48	482	participation, and increased player numbers.	
49 50	483		
51 52	484	Conclusion	
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This study provides insight into the nature and rates of tackle-related injuries occurring
amongst youth rugby union players in South Africa. The finding that tTackle-related injury
rates decreased was highest at the 2012 under-13 Craven Week tournament with increasing
age is in contrast to previous literature. On-going injury surveillance is required to determine
if this finding is repeated in future tournaments. Tackle-related injury type did not differ
across the tournaments for both <i>overall</i> and <i>time-loss</i> injuries. Skeletal and muscular
injuries were more prominent in the youngest playing group and the long-term impact of
these might need further exploration. Fatigue appears to play a role in the increasing
tackle-related injury rates as match time progresses. Further research is required to
determine the precise effect of fatigue on tackle technique proficiency and its relation to
injury. One can only create an effective injury prevention strategy once the This evidence.
along with information detailing the precise risk factors and aetiology of tackle event injuries.
may help guide the formation of effective injury prevention strategies. have been properly
determined.
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509 Contributors

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5 6 7	510	NB was granted access to analyse the data, was involved in conceptualising the manuscript.
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9	511	conducted statistical analyses and wrote the initial drafts of the manuscript. NB, JB and SH
10 11	512	collected and entered the data. All authors (ML, WV, JB, CR and SH) were involved in
12	513	conceptualising and editing drafts of the paper, in the order that they appear on the author
13 14 15	514	list.
16 17	515	
18 19	516	Competing interests
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21 22 23	517	The authors have no conflict of interest to declare.
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45	507	Data abaying statement
46 47	527	Data sharing statement
47 48 49	528	Owing to the sensitive nature of the information and appropriate medical ethics, access to a
50	529	more detailed aspect of the available dataset will be reviewed upon request and on a
51 52	530	discretionary basis. Sharing of only depersonalised and non-relatable data will be
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6 7	531	considered, once permission has been received from WV or CR (can be contacted through
8 9	532	the corresponding author).
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3 10	verall t	<u>rear</u> ackle iniuries (n)	2011	<u>2012</u> 36	2011	33	<u>2011</u> 47	<u>2012</u> 44	<u>2011</u> 25	34
5			<u> </u>	<u>00</u>	20	00	<u> 1</u>		20	<u>04</u>
6	<u>c</u>	<u>verall injury rate</u>	<u>29.2</u>	<u>50.0</u>	<u>24.7</u>	<u>36.7</u>	<u>34.4</u>	<u>32.2</u>	<u>23.8</u>	<u>33.5</u>
7			<u> 16.8 -</u>	<u>33.7 -</u>	<u>13.9 -</u>	24.2 -	<u>24.6 -</u>	<u>22.7 -</u>	<u>14.5 -</u>	<u>22.2 -</u>
კ ი	<u>9</u>	<u>5% CI</u>								
))			<u>41.6</u>	<u>66.3</u>	<u>35.5</u>	<u>49.2</u>	<u>44.3</u>	<u>41.8</u>	<u>33.1</u>	<u>44.8</u>
1	TL tack	le injuries (n)	<u>9</u>	<u>16</u>	<u>8</u>	<u>13</u>	<u>25</u>	<u>13</u>	<u>11</u>	<u>9</u>
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6	<u>9</u>	<u>5% CI</u>	20.7	33.1	16.7	22.3	25.5	14.7	16.7	14.7
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3	658	Fig.1. (a) A con	nparison	of injury ra	te (± 95%C	Cls) of 'ove	erall' tackle	-related inju	uries	
4	659	(including 'time	e-loss' ini	uries) at ea	ch South	African P	ugby Union	(SARII)		
5	660	tournament in	2011 (whi	te bars) an	d 2012 (sr	aded bars	s), and (b) a	compariso	n of	
7 8	661	injury rate (± 9	5%Cls) of	tackle-rela	ted 'time-	loss' injur	ies betweer	n each Sout	h	
)	662	African Rugby	Union (S	ARU) tourn	ament in 2	2011 (white	e bars) and	2012 (shad	ed	
1 2	663	bars). (CW13 –	under-13	Craven We	eek; GK16	– under-1	6 Grant Kh	omo Week;	AW18 –	
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Fig.1. (a) A comparison of injury rate (± 95%CIs) of 'overall' tackle-related injuries (including 'time-loss' injuries) at each South African Rugby Union (SARU) tournament in 2011 (white bars) and 2012 (shaded bars). (CW13 – under-13 Craven Week; GK16 – under-16 Grant Khomo Week; AW18 – under-18 Academy Week; CW18 – under-18 Craven Week) 181x90mm (300 x 300 DPI)



Fig.1. (b) A comparison of injury rate (± 95%CIs) of tackle-related 'time-loss' injuries between each South African Rugby Union (SARU) tournament in 2011 (white bars) and 2012 (shaded bars). (CW13 - under-13 Craven Week; GK16 - under-16 Grant Khomo Week; AW18 - under-18 Academy Week; CW18 - under-18 Craven Week) 220x106mm (300 x 300 DPI) 220x106mm (300 x 300 DPI)

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TROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cohort studies

Section/Topic	ltem #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6, 9
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5-6
		(b) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-9
		(b) Describe any methods used to examine subgroups and interactions	N/A
		(c) Explain how missing data were addressed	N/A
		(d) If applicable, explain how loss to follow-up was addressed	N/A
		(e) Describe any sensitivity analyses	N/A
Results			

Page	54	of	54
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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed	9
		eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5,9
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	9
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence	9-12
		interval). Make clear which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from	12-16
		similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.