Surf Life Saving Injuries in New Zealand between 2013 to 2017 derived from Accident Compensation Corporation Claims: Technical Report #4 to Surf Life Saving New Zealand (SLSNZ)

Te Kaporeihana Āwhina Hunga Whara

By research team members for TE HOKAI TAPUWAE – REIMAGINING SPORTS INJURY PREVENTION

Shelley N. Diewald[1,3], Patria A. Hume[1], Kirsten Malpas[6], Barry D. Wilson[1], Adam Wooler[2], Ross Merrett[2], Daniel T.P. Fong[3], Stephen Reay[4], Valance Smith[5]

[1] Sports Performance Research Institute New Zealand, Auckland University of Technology; [2] Surf Life Saving New Zealand; [3] Loughborough University; [4]Good Health Design, Auckland University of Technology; [5]Te Ara Poutama, Auckland University of Technology; [6]Accident Compensation Corporation

This report is part of a series of technical reports for the research collaboration between Surf Life Saving New Zealand (SLSNZ) and AUT Sports Performance Research Institute New Zealand (SPRINZ).

SURF LIFE SAVING NEW ZEALAND
In it for life

AUT SPORTS PERFORMANCE RESEARCH INSTITUTE NEW ZEALAND

Citation: Diewald S.N., Hume P.A., Malpas K., Wilson B.D., Wooler A., Merrett R., Fong D.T.P., Reay, S., Smith, V. Surf Life Saving Injuries in New Zealand between 2013 to 2017 derived from Accident Compensation Corporation Claims: Technical Report #4 to Surf Life Saving New Zealand (SLSNZ). SPRINZ, Auckland University of Technology, 16th June 2019. 36 pages.

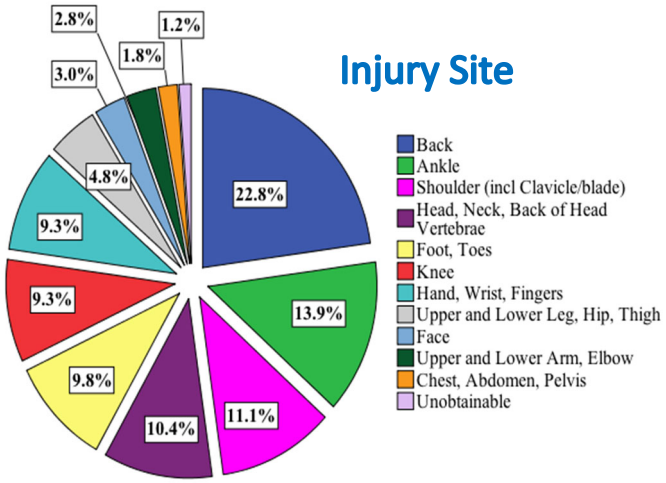
Table of Contents

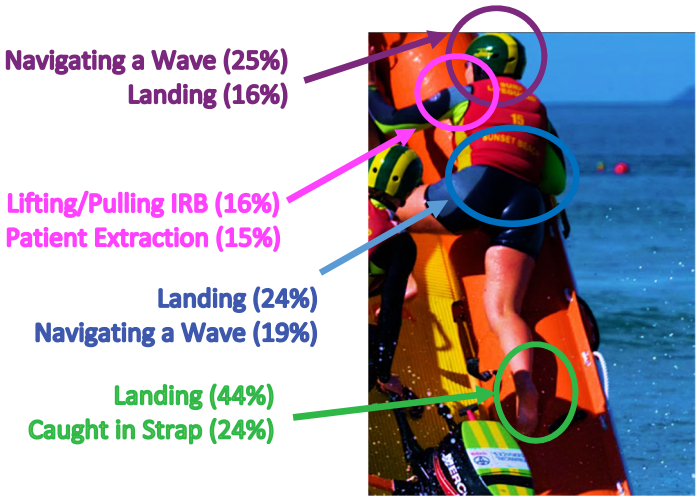
List of Tables

List of Figures

Surf Life Saving New Zealand ACC injuries - Fact Sheet

Injury Site

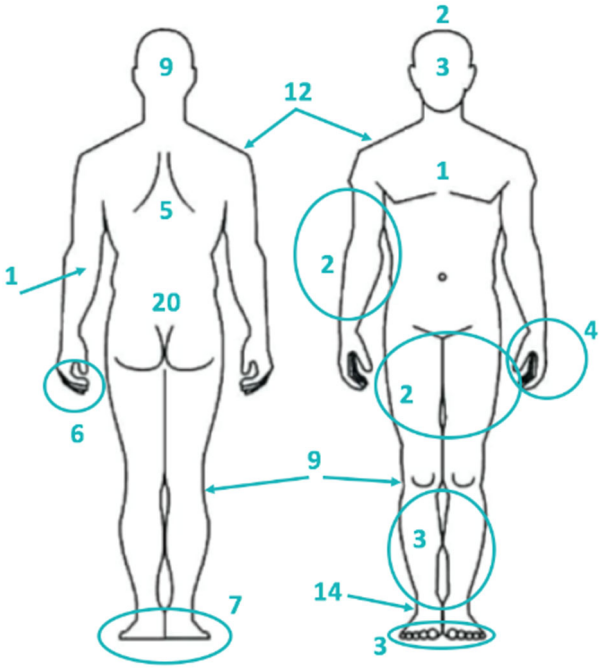




Lower Back

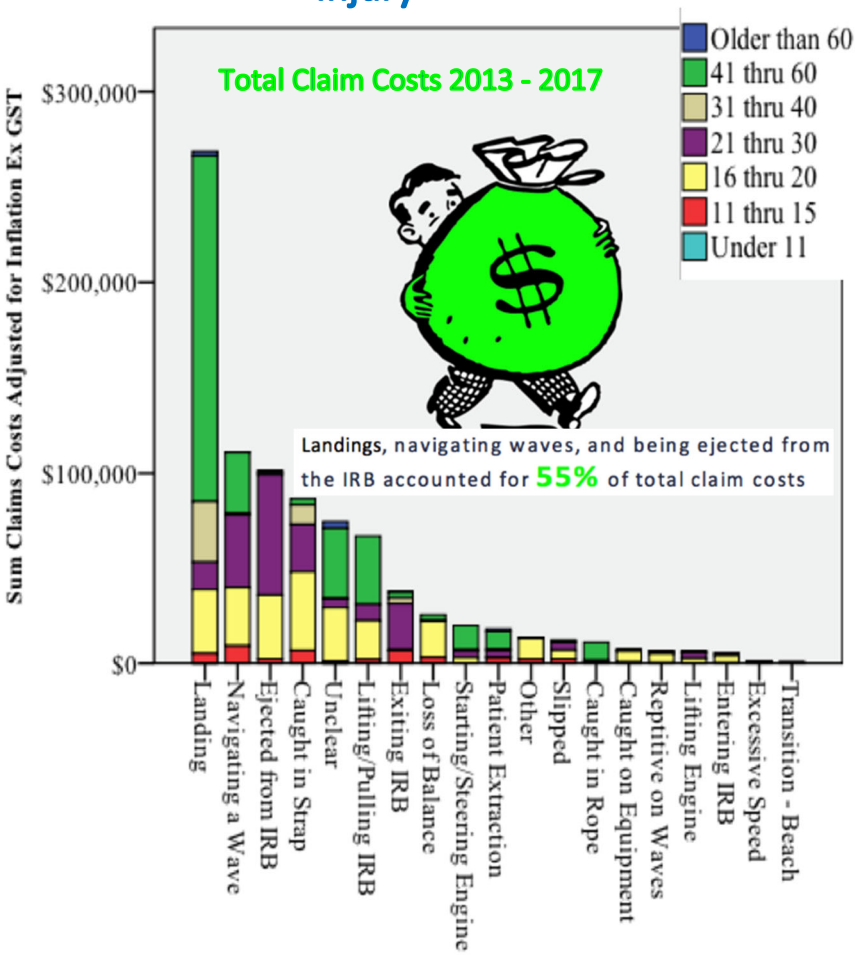
injuries made up 18.5% of all injury claims from 2013 to 2017. 1 out of 5 lower back injury claims were due to landing in the boat after being airborne in the IRB.

Incidence rates by injury site



Incidence Rates
(per 1000 members)

Mechanisms of Injury



Key Findings

- **IRBs accounted for 605 (63.3%) of MSC claims for surf lifesaving, costing ACC $875,585**
- **Younger females and older males filed the most ACC claims for surf lifesaving injuries**
- **The high incidence of lower back moderate-to-serious claims were caused by landing in the IRB (24%) and when navigating waves (19%)**
- **The foot strap was indicated as the cause of injury in 1 out of 4 ankle moderate-to-serious claims**

Diewald S.N., Hume P.A. et al. (2019): Surf Life Saving Injuries in New Zealand between 2013 to 2017 derived from Accident Compensation Corporation Claims: Technical Report #4 to Surf Life Saving New Zealand (SLSNZ).

ABSTRACT

Background: Due to their speed and manoeuvrability, inflatable rescue boats (IRB) were thought to be associated with increased risk of injury by Surf Life Saving New Zealand (SLSNZ).

Purpose: This study aimed to quantify the nature and extent of IRB-related injury as reported to the Accident Compensation Corporation (ACC) in order to develop injury prevention strategies.

Methods: A total of 956 moderate-to-serious injury (MSC) claims filed with the Accident Compensation Corporation (ACC) from 2013 to 2017 were retrospectively analysed to provide epidemiological data and related costs. The "sequence of injury prevention" approach proposed by van Mechelen, Hlobil [1] was utilised to identify risk factors, causes, and mechanisms in order to prescribe injury prevention strategies.

Results: IRBs accounted for 605 (63.3%) MSC claims for surf lifesaving, costing ACC $875,585. The incidence of injury (IR) from 2013 to 2017 was 103 per 1,000 surf lifesavers; an average of 0.41 IRB-related claims lodged per day. The most frequently injured body sites were the lower back (IR: 20/1000) and ankle (IR: 14/1000). Cause of injury was reported as landing in the IRB (IR: 23/1000). Utilisation of IRBs during surf lifesaving has a risk of injury to the lower extremities and back, particularly in younger females and to the right side of the body. Gender was statistically related to age of injury; incidence of injury for males over the age of 60 was 318 per 1,000 lifesavers.

Discussion: The nature of the injury mechanisms may contribute to the development of chronic symptoms. Results are most likely an underestimate due to crude incidence rates. Future research should evaluate current techniques, as well as consider strength intervention strategies in preventing IRB-related injuries.

Conclusion: IRB-related ACC claims lodged for surf lifesaving per-day are high. Targeted injury prevention strategies must focus on lower back and ankle injuries.

Recommendations:

1. Future research and injury prevention strategies should target ways to minimise the number and effects of landings.

INTRODUCTION

Swimming and surfing are an integral part of daily life in New Zealand, with over 14,000 kilometres of coast line extending across two major oceans [2, 3]. Surf lifesavers play an important role in keeping the public safe, and recently have come to rely less on traditional non-powered rescue aids and more heavily on powered watercrafts; such as the inflatable rescue boat (IRB) to complete open water rescues. Due to their speed and manoeuvrability, IRBs are ideal for beach patrol and surveillance. IRBs consist of two rigid inflatable pontoons supported by a removable fibreglass laminate floor, fitted with an outboard motor and additional crewing equipment (e.g. foot straps, ropes, etc.) New Zealand surf lifesavers utilise IRBs in over 50% of all rescues per year [4].

Surf Life Saving New Zealand (SLSNZ) is a governmental agency in New Zealand which coordinates the surf lifesaving activities of all the clubs in the nation. This includes the oversight of lifeguard certifications, equipment standards, and member training. The operation of an IRB typically involves two lifeguards; a driver in the rear and a crew member at front, racing through the surf simulating or performing a rescue. The crew member is responsible for keeping the IRB balanced through the surf by utilising their body weight and additional equipment to stay safely inside the boat (e.g. bow ropes, foot straps). The driver is responsible for navigating the IRB in such a way as to ensure the crews' safety. Surf lifesavers participate in regular training to prepare for IRB operation during both patrol and competition.

According to SLSNZ internal injury reports, increased use of IRBs in New Zealand may have resulted in an increase in injury incidences [5-9]. The repetitive nature of IRB operation may increase the incidence of acute and chronic injuries, thus negatively impacting the health of surf lifesavers. The pattern of injuries that occur during sport and recreational activities are often examined to identify the number, circumstances, and causal factors associated with injurious events to quantify the injury burden and to identify potential injury prevention strategies.

Workers' compensation databases (e.g. OSHA, WorkSafe) were analysed in Australia [10] and the United States [11] to assess 'surf' and 'lifeguard' injuries. Moreover, Australian epidemiological studies from 1989 – 2011 showed an increased risk of injury while operating an IRB [10, 12, 13]; the incidence of IRB surf lifesaving injuries was reported between 1.2% to 4.1% in Australia [10, 14], with high incidences of lower limb injuries [10, 15]. The actual incidence and cost of surf lifesaving injuries in New Zealand remains unknown. Soft-tissue injuries were the most common, specifically at the ankle joint, followed by fractures [10, 13, 16]. Conflicting findings regarding gender- and age- specific risk factors exist. However, there was a greater proportion of injury on the right side of the body and occurring mostly to the crew member [10, 16].

Crew member technique and training are potential risk factors of injury [17]. Crew members are positioned on the right (port) side of the pontoon, and required to lean and move to balance the boat while navigating through the surf [4]. The mechanisms of lower limb injuries may be influenced by the crew members' foot straps [16, 18]. The location of the foot straps (stance angle, width, and direction) place varying biomechanical limitations on the crew member and their technique during operation [17].

Foot straps play a significant role in the safety of the crew member by decreasing the susceptibility to ejection from the IRB. Although previously suspected as a direct cause of lower limb injury [16], the simulated removal of the right foot strap showed no signs of reduced dorsiflexion [17], a recognised risk factor of ankle sprain injuries [19-22]. Nevertheless, the removal of the right foot strap was mandated in New Zealand in 2018 (recommended in 2010 and 2014), the effects of which on crew stability and injury risk remain unknown [18, 23].

Due to the varying conditions and demands of the open ocean, and the lack of IRB-specific studies, other water-based board sports (wakeboarding, kitesurfing, and traditional surfing) and associated injuries and mechanisms were reviewed, revealing significant injuries occurring to the lower extremities after landing aerial movements [24-29]. The lower limbs may be unable to handle the excessive dynamic loads during landing, particularly when in a flexed position, suggesting increases in

lower extremity strength may help improve the ability to handle the landings [27, 30, 31]. However, only one IRB-specific intervention study exists, and no effectiveness measures were determined.

Therefore, the aim of this study was to provide a retrospective analytical review of the MSC claims and costs of surf lifesaving in New Zealand over a five-year period (2013-2017). The Accident Compensation Corporation (ACC) database contains detailed records for all reported injuries in New Zealand. Records within the ACC include the number of injury claims and the costs associated with treatment. However, specific injury details and/or associated hospitalisation times are not stored on record. The "Sequence of Injury Prevention" approach proposed by van Mechelen, Hlobil [1] was utilised to identify risk factors, causes, and mechanisms in order to prescribe injury prevention strategies. It was hypothesized that gender, age, and side of injury would be significantly associated with occurrence of lower extremity injuries and directed technique modifications and strength interventions may be an effective injury reduction strategy.

METHODS

Ethical consent

Ethical consent was obtained from the Health and Disability Ethics Committee. Informed consent from the injured participants was not obtained as de-identified data were collected from the ACC database (#380) without individual participant identification or follow-up. Ethical consent was also obtained from the Auckland University of Technology (AUT) Ethics Committee (#18380) and Loughborough University Ethics Committee (#R18-P233).

ACC database

The ACC database records and reports two types of acute personal injury claims [32], termed minor or moderate-to-serious claims (MSC). The term MSC is an accounting term utilised by ACC and is not a reflection of the severity classification of the injury recorded. These terms are defined under the 2001 Injury Prevention, Rehabilitation and Compensation (IPRC) Act, and identify ACC as the organisation responsible for meeting the costs of the injury claims lodged [32]. As defined in the 2001 IPRC Act, claimants qualify for coverage when they present with a personal acute injury as a result of an accident to any of the 30,000 ACC recognised, registered medical practitioners throughout New Zealand [32].

To make an injury claim, claimants complete a standard ACC45 injury reporting form to record injury details and ensure consistency of data recording and analyses. The injured claimant provides information about the activity resulting in injury (unless impaired), along with their personal details (e.g., age, gender, ethnicity, contact details). The registered health professional then completes the ACC45 injury reporting form by providing information regarding initial diagnosis and other relevant medical information (e.g., surgical procedure). The claim is then filed with ACC and the relevant details are entered into a central database. As detailed in the 2001 IPRC Act, ACC provides coverage for injured parties including: including medical treatment, income replacement, social and vocational rehabilitation and ancillary services (transportation and accommodation) as part of the rehabilitation for the injury [33]. There is no disincentive for making claims to ACC nor are claimants risk-rated or penalised for the number of claims they submit [33]. Personal injury coverage is guaranteed by ACC, this is offset by the restriction to sue for personal injury, except in rare circumstances for exemplary damages [33].

For a claim to be classified as MSC, the injury typically requires assistance beyond medical treatment alone [32]. As a result, MSC may involve a combination of medical care, rehabilitation costs and income replacement for employment time lost as a result of the injury [32]. For the purpose of the study, the authors evaluated MSC claims from 1st January 2013 to 31st December 2017 that resulted in any injury occurring while operating an IRB during surf lifesaving in New Zealand.

All epidemiological studies are dependent on data quality for any analysis to be undertaken [33]. A potential identified limitation related to the use of this database is the way the data are retrieved to protect client confidentiality. All claims and related costs with the potential to identify an individual

were removed from analyses [34]. All costs were inflation adjusted using the Reserve Bank inflation adjustor[1] to reflect all costs at 2017 rates with a mean inflation of 2.85 ±0.93% per year.

Data collection and analysis

Individual claims were extracted from the ACC database based on the following keywords: "IRB", "boat", "inflatable", "lifesaving", and "rescue" (n = 956) and a match index was created by the associated keyword combinations. Accident description free text analysis was conducted on claims that did not report a text match with either "IRB" or "inflatable" (n = 438). Claims specifying injuries involving coast guard rescue boats were excluded (n = 3). Claims not identifying injuries specifically related to an IRB were excluded (n = 319). Injuries occurring to patients (not surf lifesavers) were also excluded (n = 29). A total of 605 claims were kept for analysis.

Categorising decisions

Claims were categorised by year of accident, season of accident, gender, and age group at the time of injury. Age groups were defined by SLSNZ for consistency. In order to calculate injury incidence rates, 'seasons' were defined as 1st October to 30th September of the following year, to align with the active surf lifesaving patrol season and associated participation rates supplied by SLSNZ. Further free text categorisation was made by injury body site, injury type, and mechanism of injury. Body sites were grouped together based on location: "Lower Extremity", "Upper Extremity", and "Other (head, torso, back, neck)".

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics (IBM Corp. Released 2016. IBM SPSS Statistics for Macintosh 24.0. Armonk, NY: IBM Corp). Specific injury types and sites are presented as absolute numbers and percentages, separated by year, season, age, and gender. To enable identification of the rate per 1,000 people, participation data were obtained from *SLSNZ*. The source population were all eligible with a minimum of obtaining a Surf Lifeguard Award (or refresher) (earliest attainment age, 11 years). Patrol and competition injury frequencies were combined for analysis. To assess differences between genders, age groups, and side of body, risk relationships were analysed using chi-squared tests for independence ($p<0.05$), and 95% CI were constructed, where appropriate. All costs are reported in NZ Dollars ($) and excluding GST.

RESULTS

Total moderate-to-serious acc injury entitlement claims

Over the 5-year period there were 605 total MSC claims costing ACC $875,585 [equivalent to £483,553] (Figure 1). The claims and costs increased over the study period from 2013 (claims: 119, 19.7%; costs: $180,488, 20.6%) to 2016 (137 claims: 22.8%; costs: $268,744, 30.7%), and decreased in 2017 (claims: 45, 7.4%; costs: $108,689, 12.4%) (Figure 1). Total claims decreased by an average of 2 ±24 claims, and total costs decreased by an average of $17,950 ±$141,772 per reporting year over the duration of the study. As a result, the mean cost per-claim decreased from $1,517 [£838] (2013) to $979 [£541] (2017). On average, there were 0.41 total claims lodged for an IRB-related surf lifesaving injury per day. The estimated annual crude incidence of IRB-related ACC claims was 130/1000, or 13.0%, out of 4,657 surf lifesavers who may have used an IRB and therefore had a risk of injury during the seasonally adjusted study period. The highest mean cost per claim occurred in 2014 ($2,003 [£1 106]) while the lowest mean cost per claim occurred in 2015 ($816 [£451]).

[1] https://www.rbnz.govt.nz/monetary-policy/inflation-calculator

Severity moderate-to-serious injury entitlement claims

Most claims from 2013 to 2017 were classified as 'none' severity (405/605, 66.9%), followed by 'low' severity (claims: 165/605, 27.3%). There was a predominance in right side, lower extremity injuries (claims: 144/228, 63.2%; costs: $434,049, 81.9%; IR: 24/1000[2]). Out of 277 right-sided injury claims, 37 (13.4%) were caused by being caught in equipment, compared to left-sided injuries (claims: 18/212, 8.5%). Ankle injuries that occurred on the right side made up 71.4% of all ankle claims (claims: 60/84, IR: 9/1000), however there was no side difference of knee claims (right: claims: 27/56, 48.2%; IR: 4/1000) (left: claims: 29/56, 51.8%; IR: 5/1000). Of ankle claims, 25.0% (21/84) were due to being caught in equipment, compared to 10.7% of knee injury claims. Of all knee injuries, 26.8% occurred when landing in the IRB. Seasonally adjusted incidence rates per 1000 active surf lifesaving members are reported in **Table** 1.

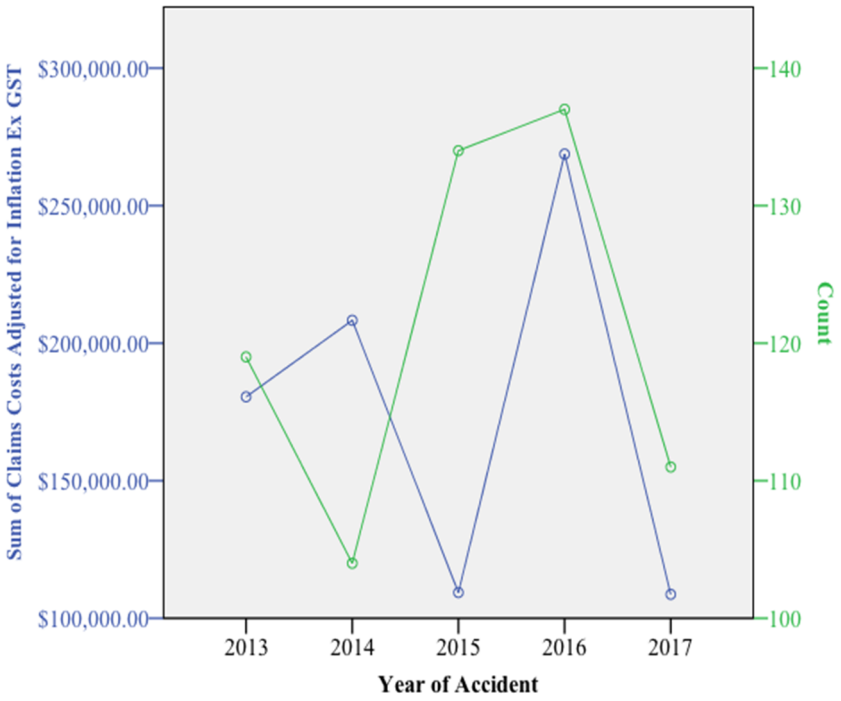


Figure 1: ACC*:* IRB*-related injury summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and associated costs from 1st January 2013 to 31st December 2017.*

[2] All incidence rates (IR) are calculated based on seasonally adjusted values (2013-2014 season to 2016-2017 season)

Table 1: Surf lifesavers in New Zealand from 2013-2014 to 2016-2017 season: IRB-*Related Injury Summary of Accident Compensation Corporation moderate-to-serious seasonally adjusted injury entitlement claims and associated injury incidence rates per 1000 surf lifesaving members per body side of anatomical location*

	Season of Accident[a]																Total			
	2013 - 2014				2014 - 2015				2015 - 2016				2016 - 2017							
	Left	None	Right	Total	Left	None	Right	Total	Left	None	Right	Total	Left	None	Right	Total	Left	None	Right	Total
Ankle	0	0	3	4	1	0	3	4	1	0	4	5	2	0	2	4	5	0	9	14
Knee	0	0	1	2	2	0	1	3	0	0	1	1	2	0	2	4	5	0	4	9
Foot	1	0	1	2	0	0	1	1	1	0	2	2	1	0	1	2	2	0	5	7
Lower Leg	0	0	0	0	0	0	1	1	0	0	1	1	1	0	0	1	1	0	2	3
Toes	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	0	2	3
Hip, Upper Leg, Thigh	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	1	2
Lower Extremity	**1**	**0**	**6**	**8**	**4**	**0**	**7**	**10**	**3**	**0**	**8**	**11**	**6**	**0**	**6**	**11**	**15**	**0**	**24**	**39**
Shoulder (incl Clavicle/blade)	1	0	1	2	2	0	2	3	1	0	2	3	1	0	2	3	5	0	7	12
Finger/thumb	1	0	1	2	1	0	0	1	0	0	1	1	1	0	1	2	2	0	4	6
Hand/wrist	0	0	0	0	1	0	0	1	1	0	0	1	0	0	1	1	2	0	2	4
Upper And Lower Arm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	2
Elbow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Upper Extremity	**3**	**0**	**2**	**5**	**3**	**0**	**3**	**6**	**2**	**0**	**4**	**6**	**2**	**0**	**4**	**6**	**9**	**0**	**15**	**24**
Lower Back/spine	1	2	1	4	1	2	0	4	1	4	1	5	1	2	1	5	6	11	4	20

Neck, Back Of Head Vertebrae	0	1	1	2	1	1	0	2	1	1	1	2	1	1	1	3	4	4	2	9
Upper Back/spine	0	0	0	0	1	1	0	2	0	0	0	0	0	1	0	1	1	3	1	5
Face	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	2	1	3
Head (except Face)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	2
Chest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Abdomen/pelvis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1
Ear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	**1**	**4**	**2**	**6**	**3**	**5**	**2**	**9**	**3**	**6**	**2**	**11**	**3**	**5**	**3**	**11**	**13**	**20**	**9**	**42**
Unobtainable	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**

Only seasons for which participant data were available and injury claims for the entirety of the season were collected were analysed for incidence rates. N=105 claims were removed from the 2012-2013 season and 2017-2018 season. The active surf lifesaving patrol seasons runs from 1 October - 30 April the following year. For the purposes of this study, the inactive season ran from 1 May to 30 September. Incidence rates were calculated based on this season (e.g. 1 October 2013 - 30 September 2014). Population was determined as all active surf lifesavers in New Zealand that were surf lifeguard certified and active during that season. Population data were obtained from SLSNZ. Incidence rates were calculated and reported per 1000 active surf lifesaving members

Injury site moderate to serious injury entitlement claims

Table 2 and

Table 3 illustrate the number, incidence rate (IR[3]), and total cost per year per injury site. "Other" injuries (claims: 230/605, 38.0%; costs: $122,565, 14.0%; IR: 42/1000) accounted for the most injury claims, followed by "lower extremity" (claims: 228/605, 37.7%; costs: $529,922, 60.5%; IR: 39/1000) and "upper extremity" (claims: 140/605, 23.1%; costs: $199,416, 22.8%; IR: 24/1000). The most commonly injured sites over the study period were the lower back/spine (claims: 112/605, 18.5%; costs: $37,791, 4.3%; IR: 20/1000), ankle (claims: 84/605, 13.9%; costs: $280,588, 32.0%; IR: 14/1000), shoulder (incl. clavicle/blade) (claims: 67/605, 11.1%; costs: $102,185, 11.7%; IR: 12/1000), and knee (claims: 56/605, 9.3%; costs: $93,797, 10.7%; IR: 9/1000). There was a 4-fold increase in average claim cost between lower back and ankle claims. The most expensive injury site by cost per claim over the study period were injuries to the lower leg (claims: 16/605, 2.6%; costs: $6,681 ±$12,986; IR: 3/1000), unobtainable (claims: 7/605, 1.2%; costs: $3,383 ±$7,026; IR: 2/1000), elbow (claims: 5/605, 0.8%; costs: $3,345 ±$6 510; IR: 1/1000), and ankle (claims: 84/605, 13.9 %; costs: $3,340 ±$9,260).

From 2013 to 2017, 43.6% (264/605) of claims were made by females, who had the highest incidence of injury (IR: 112/1000). The most commonly injured site of female claims was the lower back (claims: 47/264, 17.8%; costs: $13,079, 3.7%; IR: 21/1000), ankle (claims: 36/264, 13.6%; costs: $164,674, 44.1%; IR: 14/1000), and shoulder (claims: 29/264, 11.0%; costs: $17,460, 4.7%; IR: 13/1000). There was a 4-fold increase in average claim cost from lower back claims to ankle. Annual costs of all ankle claims increased $965 ±$2,739 each year over the study period, while lower back costs decreased $242 ±$103 each year. In 2013, shoulder injury claims accounted for 28.6% of total costs (15.1% of 2013 claims) compared to 2014 to 2017 (claims: 10.1 ±1.3%; total costs: 7.2 ±1.1%).

Injury types of moderate to serious injury entitlement claims

The most common injury types from 2013 to 2017 were soft tissue injuries such as contusions, strains, and sprains (claims: 493/605, 81.5%; costs: $755 ±$2,572, 42.5%; *IR*: 86/1000) and fractures/dislocations (claims: 55/605, 9.1%; costs: $7,503 ±$12,340, 47.1%; *IR*: 10/1000) (Table 4 and Table 5). Lower extremity soft tissue injuries (claims: 178/605) accounted for 29.4% of total injury claims reported. Lower extremity fractures comprised 37.4% of total claim costs over the study period. In 2017, lower back soft tissue injury claims (28/111) comprised 25.2% of annual claims and 34.8% of annual costs. Shoulder soft tissue injury claims decreased from 2013 (claims: 16/605, 2.6%; costs: $3,072 ±$5,809, 5.6%) to 2017 (claims: 10/605, 1.7%; costs: $440 ±$389, 0.5%) (**Error! Reference source not found.**)

Fractures accounted for 57.9% of total female costs (claims: 24/55; *IR*: 10/1000) and 39.2% of total male costs (claims: 31/55; *IR*:10/1000). Males claimed 34/52 knee soft tissue injuries (average costs: $1,566 ±2,690; total cost: $53,251) compared to females (claims: 18/52, average costs: $2,188 ±$8,002; total cost: $39,380).

[3] All incidence rates (*IR*) are calculated based on seasonally adjusted values (2013-2014 season to 2016-2017 season)

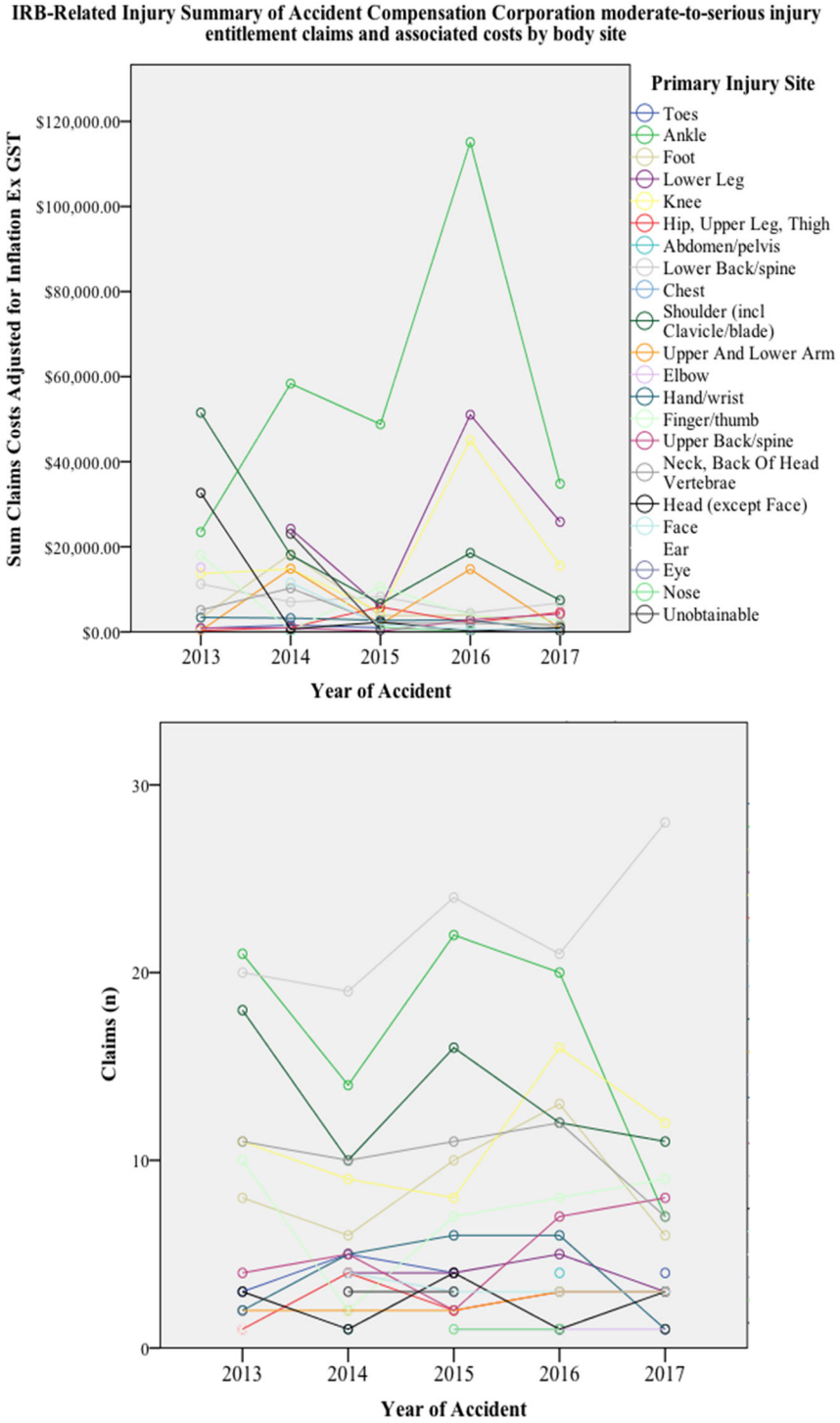


Figure 2 - IRB-*related injury summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and associated costs by body site.*

Table 2: Surf lifesavers in New Zealand from 2013 to 2017: IRB*-related injury summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and associated costs per anatomical location*

	Year of Accident												Claims Costs Adjusted for Inflation Ex GST		
	2013		2014		2015		2016		2017						
	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Cost per Claim (NZD)	% of Costs (NZD)	Sum of Costs (NZD)
Ankle	21	17.6	14	13.5	22	16.4	20	14.6	7	6.3	84	13.9	$3,340	32.0	$280,588
Knee	11	9.2	9	8.7	8	6.0	16	11.7	12	10.8	56	9.3	$1,674.95	10.7	$93,797
Foot	8	6.7	6	5.8	10	7.5	13	9.5	6	5.4	43	7.1	$710	3.5	$30,529
Lower Leg	0	0.0	4	3.8	4	3.0	5	3.6	3	2.7	16	2.6	$6,681	12.2	$106,896
Toes	3	2.5	5	4.8	4	3.0	0	0.0	4	3.6	16	2.6	$263	0.5	$4,215
Hip, Upper Leg, Thigh	1	0.8	4	3.8	2	1.5	3	2.2	3	2.7	13	2.1	$1,069	1.6	$13,898
Lower Extremity	**44**	**37**	**42**	**40**	**50**	**37**	**57**	**42**	**35**	**32**	**228**	**38**	**$13,739**	**61**	**$529,922**
Shoulder (incl Clavicle/blade)	18	15.1	10	9.6	16	11.9	12	8.8	11	9.9	67	11.1	$1,525	11.7	$102,185
Finger/thumb	10	8.4	2	1.9	7	5.2	8	5.8	9	8.1	36	6.0	$989	4.1	$35,621
Hand/wrist	2	1.7	5	4.8	6	4.5	6	4.4	1	0.9	20	3.3	$616	1.4	$12,312
Upper And Lower Arm	2	1.7	2	1.9	2	1.5	3	2.2	3	2.7	12	2.0	$2,714	3.7	$32,572
Elbow	2	1.7	0	0.0	1	0.7	1	0.7	1	0.9	5	0.8	$3,345	1.9	$16,725
Upper Extremity	**34**	**29**	**19**	**18**	**32**	**24**	**30**	**22**	**25**	**23**	**140**	**23**	**$9,190**	**23**	**$199,416**
Lower Back/spine	20	16.8	19	18.3	24	17.9	21	15.3	28	25.2	112	18.5	$337	4.3	$37,791
Neck, Back Of Head Vertebrae	11	9.2	10	9.6	11	8.2	12	8.8	7	6.3	51	8.4	$415	2.4	$21,164
Upper Back/spine	4	3.4	5	4.8	2	1.5	7	5.1	8	7.2	26	4.3	$346	1.0	$9,009

Face	0	0.0	4	3.8	3	2.2	3	2.2	3	2.7	13	2.1	$1,100	1.6	$14,298
Head (except Face)	3	2.5	1	1.0	4	3.0	1	0.7	3	2.7	12	2.0	$3,066	4.2	$36,787
Chest	2	1.7	0	0.0	3	2.2	0	0.0	1	0.9	6	1.0	$177	0.1	$1,060
Abdomen/pelvis	0	0.0	1	1.0	0	0.0	4	2.9	0	0.0	5	0.8	$209	0.1	$1,046
Ear	1	0.8	0	0.0	1	0.7	0	0.0	0	0.0	2	0.3	$143	0.0	$286
Nose	0	0.0	0	0.0	1	0.7	1	0.7	0	0.0	2	0.3	$542	0.1	$1,084
Eye	0	0.0	0	0.0	0	0.0	1	0.7	0	0.0	1	0.2	$40	0.0	$40
Other	**41**	**34**	**40**	**38**	**49**	**37**	**50**	**36**	**50**	**45**	**230**	**38**	**$6,375**	**14**	**$122,565**
Unobtainable	**0**	**0.0**	**3**	**2.9**	**3**	**2.2**	**0**	**0.0**	**1**	**0.9**	**7**	**1.2**	**$3,383**	**2.7**	**$23,682**

All costs are inflation adjusted to 2017 values

Table 3: Surf lifesavers in New Zealand from 2013-2014 to 2016-2017 season: IRB*-related injury summary of Accident Compensation Corporation moderate-to-serious seasonally adjusted injury entitlement claims and associated injury incidences per anatomical location per 1000 surf lifesaving members.*

	Season of Accident[a]												Total		
	2013 - 2014			2014 - 2015			2015 - 2016			2016 - 2017					
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members
Ankle	4	3	4	5	4	5	5	4	4	1	2	2	15	14	14
Knee	3	3	3	1	1	1	5	4	4	0	2	1	9	10	9
Foot	2	1	1	3	2	2	4	1	2	2	1	1	11	5	7
Lower Leg	1	0	1	0	1	1	2	1	1	0	1	1	3	4	3
Toes	2	1	1	1	1	1	0	0	0	1	0	1	4	2	3
Hip, Upper Leg, Thigh	1	1	1	1	1	1	0	1	1	0	0	0	2	3	2
Lower Extremity	**12**	**9**	**10**	**11**	**10**	**11**	**15**	**11**	**12**	**5**	**7**	**6**	**43**	**37**	**39**
Shoulder (incl Clavicle/blade)	4	3	3	4	3	3	4	3	3	2	2	2	13	10	12
Finger/thumb	2	1	1	2	1	1	1	2	2	3	1	2	7	5	6
Hand/wrist	1	1	1	2	0	1	2	0	1	2	0	1	6	2	4
Upper And Lower Arm	1	0	0	0	1	0	1	1	1	0	1	1	2	2	2
Elbow	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1
Upper Extremity	**6**	**5**	**6**	**8**	**4**	**6**	**8**	**6**	**7**	**7**	**4**	**6**	**30**	**20**	**24**
Lower Back/spine	4	4	4	7	4	6	5	5	5	5	6	6	21	19	20
Neck, Back Of Head Vertebrae	4	1	2	2	3	2	1	4	3	1	2	2	7	10	9
Upper Back/spine	3	0	2	1	0	0	2	1	2	1	2	2	7	4	5
Face	1	0	1	1	1	1	1	0	1	0	1	0	3	2	3

Head (except Face)	1	1	1	1	0	0	1	0	0	1	1	1	3	2	2
Chest	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1
Abdomen/pelvis	0	0	0	0	0	0	0	2	1	0	0	0	0	2	1
Ear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nose	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Eye	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Other	**12**	**7**	**9**	**12**	**10**	**11**	**9**	**13**	**12**	**10**	**12**	**11**	**43**	**41**	**42**
Unobtainable	**1**	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**

a. Only seasons for which participant data were available and injury claims for the entirety of the season were collected were analysed for incidence rates. A total of 105 claims were removed from the 2012-2013 season and 2017-2018 season. The active surf lifesaving patrol seasons runs from 1st of October to 30th of April the following year. For the purposes of this study, the inactive season ran from 1st of May to 30th of September. Incidence rates were calculated based on this season (e.g. 1 October 2013 - 30 September 2014). Population was determined as all active surf lifesavers in New Zealand that were surf lifeguard certified and active during that season. Population data were obtained from *SLSNZ*. Incidence rates were calculated and reported per 1000 active surf lifesaving members

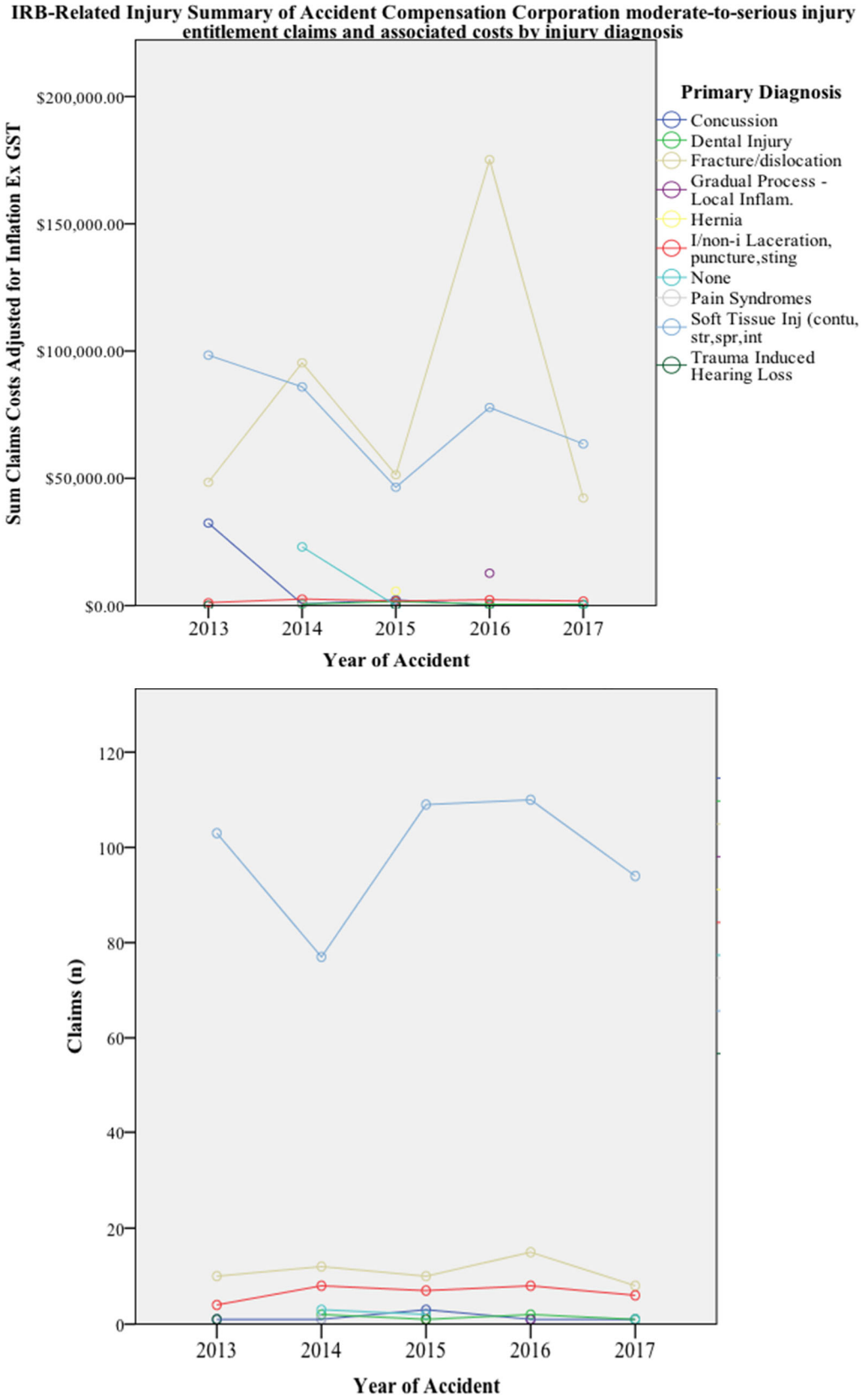


Figure 3 - IRB-*Related Injury Summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and associated costs by injury diagnosis.*

Table 4: Surf lifesavers in New Zealand from 2013 to 2017: IRB*-related injury summary of Accident Corporation Compensation moderate-to-serious injury entitlement claims and associated costs per injury diagnosis.*

	Year of Accident										Claims Costs Adjusted for Inflation Ex GST				
	2013		2014		2015		2016		2017						
	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Cost per Claim (NZD)	% of Total (NZD)	Sum of Costs (NZD)
Soft tissue injury (contusion, strain, sprain)	103	86.6	77	74.0	109	81.3	110	80.3	94	84.7	493	81.5	$755	42.5	$372,098
Fracture/dislocation	10	8.4	12	11.5	10	7.5	15	10.9	8	7.2	55	9.1	$7,503	47.1	$412,690
I/non-i Laceration, puncture, sting	4	3.4	8	7.7	7	5.2	8	5.8	6	5.4	33	5.5	$290	1.1	$9,585
Concussion	1	0.8	1	1.0	3	2.2	1	0.7	1	0.9	7	1.2	$5,139	4.1	$35,973
None	0	0.0	3	2.9	2	1.5	0	0.0	1	0.9	6	1.0	$3,874	2.7	$23,245
Dental injury	0	0.0	2	1.9	1	0.7	2	1.5	1	0.9	6	1.0	$520	0.4	$3,120
Trauma induced hearing Loss	1	0.8	0	0.0	1	0.7	0	0.0	0	0.0	2	0.3	$143	0.0	$286
Pain syndromes	0	0.0	1	1.0	0	0.0	0	0.0	0	0.0	1	0.2	$154	0.0	$154
Hernia	0	0.0	0	0.0	1	0.7	0	0.0	0	0.0	1	0.2	$5,721	0.7	$5,721
Gradual process - Local inflammation.	0	0.0	0	0.0	0	0.0	1	0.7	0	0.0	1	0.2	$12,713	1.5	$12,713

All costs are inflation adjusted to 2017 values

Table 5: Surf lifesavers in New Zealand from 2013-2014 to 2016-2017 season: IRB*-related injury summary of Accident Compensation Corporation moderate-to-serious seasonally adjusted injury entitlement claims and associated incidence rates per 1000 surf lifesaving members per injury diagnosis*

	Season of Accident[a]												Total		
	2013 - 2014			2014 - 2015			2015 - 2016			2016 - 2017					
	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members
Soft tissue injury (contusion, strain, sprain)	26	16	20	26	20	22	26	25	25	17	20	19	93	81	86
Fracture/dislocation	3	3	8	2	2	2	3	3	3	2	2	2	10	10	10
I/non-i Laceration, puncture, sting	2	2	3	2	1	2	3	1	2	2	1	2	9	5	7
Concussion	0	0	1	1	0	0	1	0	0	1	0	0	3	0	1
None	1	1	0	0	1	0	0	0	0	0	0	0	1	2	1
Dental injury	0	0	0	1	0	0	1	0	0	0	0	0	2	1	1
Trauma induced hearing Loss	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Pain syndromes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hernia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gradual process - Local Inflammation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

a. Only seasons for which participant data were available and injury claims for the entirety of the season were collected were analysed for incidence rates. A total of 105 claims were removed from the 2012-2013 season and 2017-2018 season. The active surf lifesaving patrol seasons runs from 1st of October to 30th of April the following year. For the purposes of this study, the inactive season ran from 1st of May to 30th of September. Incidence rates were calculated based on this season (e.g. 1 October 2013 - 30 September 2014). Population was determined as all active surf lifesavers in New Zealand that were sur lifeguard certified and active during that season. Population data were obtained from *SLSNZ*. Incidence rates were calculated and reported per 1000 active surf lifesaving members

Injury mechanisms of moderate-to-serious injury entitlement claims

Floorboard injuries (claims: 173/605, 28.6%; costs: $306,458, 35.0%; *IR*: 30/1000) were the most common self-reported causes of injury. Floorboard-related injuries occurred during landing (claims: 133/605, 22.0%; costs: $268,609, 30.7%; *IR*: 23/1000), loss of balance (claims: 29/605, 4.8%, costs: $25,821, 2.9%; *IR*: 5/1000), and slipping (claims: 11/605, 1.8%; costs: $12,028, 1.4%; *IR*: 2/1000). Open water injuries occurred in 165/605 claims (27.3%) totalling $220,178 (25.1% of total costs). Only 9.3% (*IR*: 11/1000) of all claims were caused by being caught on equipment: foot strap (claims: 33/605, 5.5%; costs: $86,588, 9.9%; *IR*: 6/1000), rope (claims: 9/605, 1.5%; costs: $10,876, 1.2%; *IR*: 2/1000), and other (claims: 14/605, 2.3%; costs: $7,191, 0.8%; *IR*: 3/1000). Caught in the foot strap was reported in 14.0% of lower extremity claims (claims: 32/228; costs: $2,696 ±$6,464). Most lower extremity injuries occurred during landing (claims: 69/228, 30.3%; costs: $3,315 ±$10,299) and navigating a wave (claims: 25/228, 11.0%; costs: $2,232 ±$6,052). The most floorboard injuries occurred in 2016 while open water injuries were more common in 2015. There were no claims in 2017 due to being caught in the foot straps. The most patient extraction caused injuries occurred in 2013 (claims: 11/605, costs: $5,079) and decreased by an average 1.3 ±3.9 claims ($977 ±$4,368) per year (**Error! Reference source not found.** and Table 6).

Females showed a higher incidence of injuries due to being caught in the strap (*IR*: 8/1000) compared to males (*IR*: 4/1000) (Table 9). Upper extremity claims were mainly caused by navigating waves (claims: 21/140, 15.0%; costs: $1,083 ±$3,241) and patient extraction (claims: 18/140, 12.9%; costs: $397 ±$313) (Table 6 and Table 7). Males made up the majority of equipment manoeuvre injuries (claims: 69/107, 64.5%; costs: $93,717, 83.7%; *IR*: 20/1000): lifting engines (claims: 12/107, 11.2%; costs: $2,497, 2.2%; *IR*: 3/1000), lifting/pulling IRB*s* (claims: 30/107, 28%; costs: $63,297, 56.6%; *IR*: 10/1000), starting/steering engines (claims: 5/107, 4.7%; costs: $14,926, 13.3%; *IR*: 1/1000), and patient extraction (claims: 22/107, 20.6%; costs: $12,998, 11.6%; *IR*: 6/1000) (Table 7).

Most injuries were sustained by surf lifesavers aged 16 to 20 (claims: 225/605, 37.2%; costs: $246,473, 28.1%; *IR*: 134/1000), followed by lifesavers aged 41 to 60 (claims: 119/605, 19.7%; costs: $330,961, 37.8%; *IR*: 159/1000). The main causes of injury from age 16 to 20 was landing (claims: 55/169) and navigating a wave (claims: 30/169). 38.8% of total costs from 2013 to 2017 were claimed by patients over the age of 40. The main causes of injury to the older population (over 40) was landing (claims: 27/104) and lifting/pulling the IRB (claims: 19/104). Females made up roughly half of claims under the age 30 (claims: 231/443, 52.1%; costs: $275,108, 56.6%), while males made up most claims over the age of 30 (claims: 129/162, 79.6%; costs: $29,510, 74.9%). Surf lifesavers over the age of 60 had the highest injury incidence rate, 211/1000 members (21.1%) (Table 8).

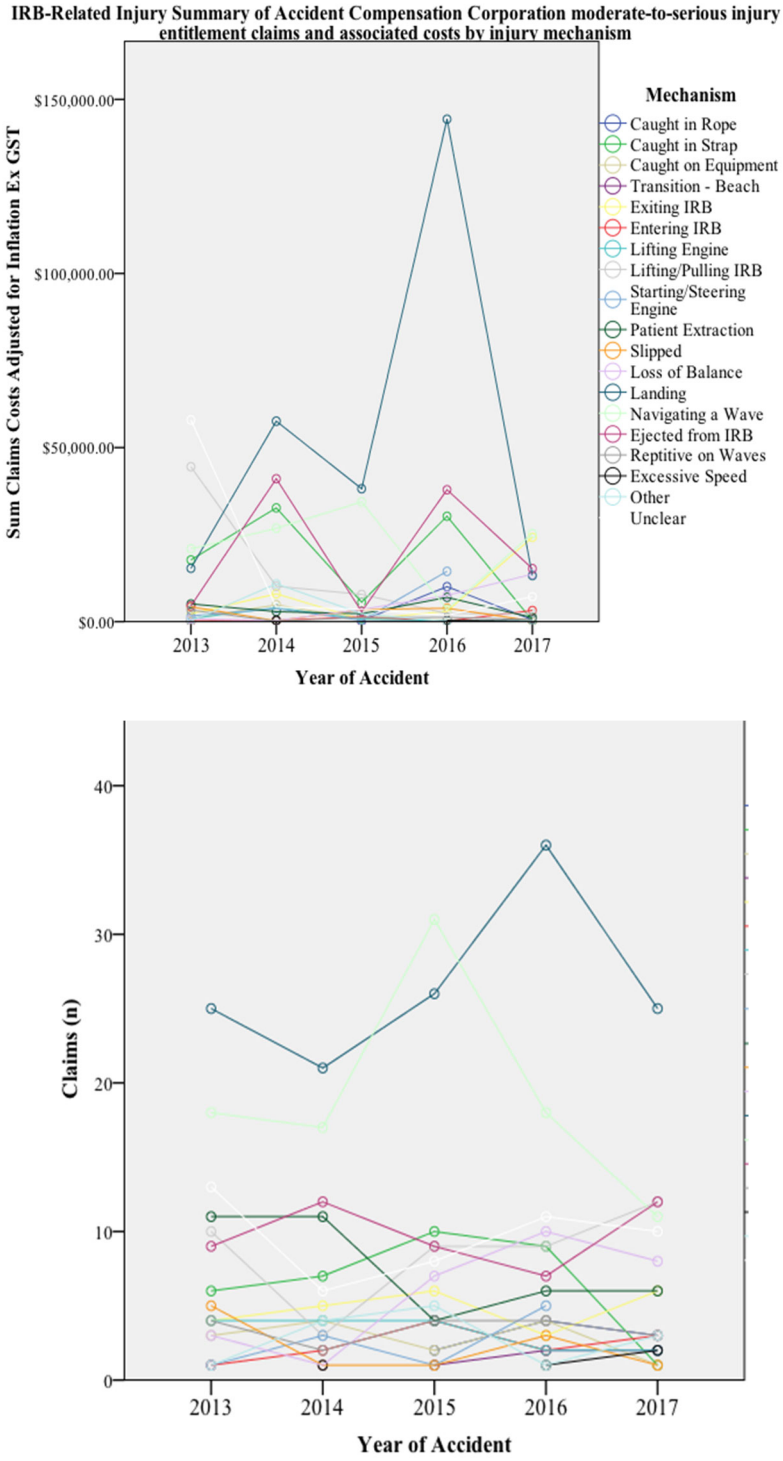


Figure 4 - IRB-*Related Injury Summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and associated costs by injury mechanism*

Table 6: Surf lifesavers in New Zealand from 2013 to 2017: IRB*-related injury summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and associated costs per injury mechanism*

	Year of Accident										Claims Costs Adjusted for Inflation Ex GST				
	2013		2014		2015		2016		2017						
	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Claims (n)	Total Claims (%)	Cost per Claim (NZD)	% of Total (NZD)	Sum of Costs (NZD)
Caught in Rope	0	0.0	0	0.0	2	1.5	4	2.9	3	2.7	9	1.5	$1,208	1.2	$10,876
Caught in Strap	6	5.0	7	6.7	10	7.5	9	6.6	1	0.9	33	5.5	$2,624	9.9	$86,588
Caught on Equipment[a]	3	2.5	4	3.8	2	1.5	4	2.9	1	0.9	14	2.3	$514	0.8	$7,191
Caught in IRB **Equipment Injuries**	**9**	**8**	**11**	**11**	**14**	**10**	**17**	**12**	**5**	**5**	**56**	**9**	**$4,346**	**12**	**$104,655**
Transition - Beach[b]	1	0.8	0	0.0	1	0.7	2	1.5	2	1.8	6	1.0	$113	0.1	$680
Exiting IRB	4	3.4	5	4.8	6	4.5	3	2.2	6	5.4	24	4.0	$1,586	4.3	$38,065
Entering IRB	1	0.8	2	1.9	4	3.0	2	1.5	3	2.7	12	2.0	$437	0.6	$5,246
Transition Injuries	**6**	**5.0**	**7**	**6.7**	**11**	**8.2**	**7**	**5.1**	**11**	**9.9**	**42**	**6.9**	**$2,136**	**5.0**	**$43,990**
Lifting Engine	4	3.4	4	3.8	4	3.0	2	1.5	2	1.8	16	2.6	$385	0.7	$6,154
Lifting/Pulling IRB	10	8.4	3	2.9	9	6.7	9	6.6	12	10.8	43	7.1	$1,561	7.7	$67,129
Starting/Steering Engine	1	0.8	3	2.9	1	0.7	5	3.6	0	0.0	10	1.7	$2,021	2.3	$20,207
Patient Extraction[c]	11	9.2	11	10.6	4	3.0	6	4.4	6	5.4	38	6.3	$485	2.1	$18,417
Equipment Maneuver Injuries	**26**	**21.8**	**21**	**20.2**	**18**	**13.4**	**22**	**16.1**	**20**	**18.0**	**107**	**17.7**	**$4,451**	**12.8**	**$111,906**
Slipped	5	4.2	1	1.0	1	0.7	3	2.2	1	0.9	11	1.8	$1,093	1.4	$12,028
Loss of Balance	3	2.5	1	1.0	7	5.2	10	7.3	8	7.2	29	4.8	$890	2.9	$25,821
Landing[d]	25	21.0	21	20.2	26	19.4	36	26.3	25	22.5	133	22.0	$2,020	30.7	$268,609
Floorboard Injuries	**33**	**27.7**	**23**	**22.1**	**34**	**25.4**	**49**	**35.8**	**34**	**30.6**	**173**	**28.6**	**$4,003**	**35.0**	**$306,458**
Navigating a Wave	18	15.1	17	16.3	31	23.1	18	13.1	11	9.9	95	15.7	$1,168	12.7	$110,973
Ejected from IRB	9	7.6	12	11.5	9	6.7	7	5.1	12	10.8	49	8.1	$2,073	11.6	$101,554
Repetitive on Waves[e]	4	3.4	2	1.9	4	3.0	4	2.9	3	2.7	17	2.8	$380	0.7	$6,464
Excessive Speed	0	0.0	1	1.0	0	0.0	1	0.7	2	1.8	4	0.7	$296	0.1	$1,186
Open Water Injuries	**31**	**26.1**	**32**	**30.8**	**44**	**32.8**	**30**	**21.9**	**28**	**25.2**	**165**	**27.3**	**$3,917**	**25.1**	**$220,178**

Other	1	0.8	4	3.8	5	3.7	1	0.7	3	2.7	14	2.3	$981	1.6	$13,736
Unclear[f]	13	10.9	6	5.8	8	6.0	11	8.0	10	9.0	48	7.9	$1,555	8.5	$74,662

Mechanisms were categorised by free text analysis. All costs were inflation adjusted to 2017 values.

a. Other equipment includes metal, sides of the pontoon, etc.

b. Injuries involving movement on the beach, prior to or following IRB operation

c. Including injuries to both the IRB crew member and the patient being extracted (if a surf lifesaver)

d. Injuries occurring upon landing after aerial movement while inside the IRB and on water

e. Injuries described as occurring due to the repetitive nature of IRB operation

f. Mechanism of injury was not specified or was unclear

Table 7: Surf lifesavers in New Zealand from 2013-2014 to 2016-2017 season: IRB*-related injury summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims and incidence rates per 1000 surf lifesaving members per injury mechanism*

	Season of Accident*												Total		
	2013 - 2014			2014 - 2015			2015 - 2016			2016 - 2017					
	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members	Female Incidence per 1000 members	Male Incidence per 1000 members	Total Incidence per 1000 members
Caught in Rope	0	0	0	1	0	0	1	0	0	2	0	1	4	1	2
Caught in Strap	3	0	2	3	2	2	3	2	2	0	0	0	8	4	6
Caught on Equipment[a]	1	1	1	0	1	0	2	0	1	0	0	0	3	3	3
Caught in IRB **Equipment Injuries**	**4**	**2**	**2**	**4**	**3**	**3**	**5**	**3**	**4**	**2**	**1**	**1**	**14**	**8**	**11**
Transition - Beach[b]	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1
Exiting IRB	1	1	1	1	1	1	0	1	1	1	2	1	3	5	4
Entering IRB	1	0	0	1	1	1	1	0	0	0	1	1	3	2	2
Transition Injuries	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**2**	**7**	**8**	**7**
Lifting Engine	2	1	1	0	1	0	1	1	1	0	0	0	2	3	3
Lifting/Pulling IRB	1	3	2	3	1	2	0	3	2	2	3	3	6	10	8
Starting/Steering Engine	0	0	0	1	0	1	2	1	1	0	0	0	3	1	2
Patient Extraction[c]	4	2	3	0	2	1	2	1	1	1	1	1	7	6	6
Equipment Maneuver Injuries	**7**	**6**	**6**	**4**	**4**	**4**	**4**	**6**	**5**	**3**	**4**	**4**	**18**	**20**	**19**
Slipped	1	1	1	0	0	0	1	0	1	0	0	0	3	1	2
Loss of Balance	1	0	0	2	1	1	3	1	2	2	1	2	7	4	5
Landing[d]	6	3	4	7	4	6	7	7	7	6	6	6	27	21	23
Floorboard Injuries	**7**	**4**	**5**	**9**	**6**	**7**	**12**	**9**	**10**	**8**	**7**	**8**	**37**	**26**	**30**
Navigating a Wave	5	3	4	6	6	6	4	6	5	1	3	2	16	18	17
Ejected from IRB	3	2	2	3	2	2	2	2	2	1	2	2	9	8	9
Repetitive on Waves[e]	1	1	1	0	1	0	1	1	1	1	0	1	4	3	3
Excessive Speed	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1
Open Water Injuries	**9**	**6**	**7**	**9**	**9**	**9**	**7**	**9**	**8**	**4**	**6**	**5**	**30**	**30**	**30**

Other	2	0	1	1	1	1	1	0	0	1	0	1	5	1	3
Unclear[f]	1	3	2	3	1	2	3	2	2	1	1	1	7	8	8

* Only seasons for which participant data were available and injury claims for the entirety of the season were collected were analysed for incidence rates. A total of 105 claims were removed from the 2012-2013 season and 2017-2018 season. The active surf lifesaving patrol seasons runs from 1 October - 30 April the following year. For the purposes of this study, the inactive season ran from 1st of May to 30th of September. Incidence rates were calculated based on this season (e.g. 1 October 2013 - 30 September 2014). Population was determined as all active surf lifesavers in New Zealand that were surf lifeguard certified and active during that season. Population data were obtained from *SLSNZ*. Incidence rates were calculated and reported per 1000 active surf lifesaving members

Mechanisms were categorised by free text analysis. All costs were inflation adjusted to 2017 values.

a. Other equipment includes metal, sides of the pontoon, etc.

b. Injuries involving movement on the beach, prior to or following IRB operation

c. Including injuries to both the IRB crew member and the patient being extracted (if a surf lifesaver)

d. Injuries occurring upon landing after aerial movement while inside the IRB and on water

e. Injuries described as occurring due to the repetitive nature of IRB operation

f. Mechanism of injury was not specified or was unclear

Table 8: Surf lifesavers in New Zealand from 2013-2014 to 2016-2017 season: IRB-*Related injury summary of Accident Compensation Corporation moderate-to-serious seasonally adjusted injury entitlement claims and associated injury incidences per age group per 1000 surf lifesaving members*

	Season of Accident				Total
	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017	
	Incidence Rate per 1000 members	Incidence Rate per 1000 members	Incidence Rate per 1000 members	Incidence Rate per 1000 members	Incidence Rate per 1000 members
11 through 15 (years)	17	22	14	21	84
16 through 20 (years)	26	30	31	21	134
21 through 30 (years)	37	27	33	28	151
31 through 40 (years)	25	23	29	19	114
41 through 60 (years)	27	32	51	22	159
Older than 60 (years)	23	73	78	14	211

Only seasons for which participant data were available and injury claims for the entirety of the season were collected were analysed for incidence rates. A total of 105 claims were removed from the 2012-2013 season and 2017-2018 season. The active surf lifesaving patrol seasons runs from 1st of October to 30th of April the following year. For the purposes of this study, the inactive season ran from 1st of May to 30th of September. Incidence rates were calculated based on this season (e.g. 1 October 2013 - 30 September 2014). Population was determined as all active surf lifesavers in New Zealand that were surf lifeguard certified and active during that season. Population data were obtained from *SLSNZ*. Incidence rates were calculated and reported per 1000 active surf lifesaving members

Table 9: IRB-*related injury summary of Accident Compensation Corporation moderate-to-serious injury entitlement claims of anatomical group by total number of claims and costs per age group (separated by gender) by surf lifesavers in New Zealand from 2013-2017*

	Under 11		11 thru 15		16 thru 20		21 thru 30		31 thru 40		41 thru 60		Older than 60	
	Female / Male		Female / Male		Female / Male		Female / Male		Female / Male		Female / Male		Female / Male	
	Claims (n)	% of Total Cost (age range)	Claims (n)	% of Total Cost (age range)	Claims (n)	% of Total Cost (age range)	Claims (n)	% of Total Cost (age range)	Claims (n)	% of Total Cost (age range)	Claims (n)	% of Total Cost (age range)	Claims (n)	% of Total Cost (age range)
Ankle	0 / 0	0.0 / 0.0	5 / 5	8.6 / 16.7	19 / 14	16.0 / 13.2	8 / 12	14.8 / 16.2	0 / 7	0.0 / 28.0	4 / 10	16.0 / 10.6	0 / 0	0.0 / 0.0
Knee	0 / 0	0.0 / 0.0	4 / 4	6.9 / 13.3	9 / 12	7.6 / 11.3	3 / 9	5.6 / 12.2	1 / 1	14.3 / 4.0	1 / 10	4.0 / 10.6	1 / 1	100 / 10.0
Foot	0 / 0	0.0 / 0.0	4 / 2	6.9 / 6.7	14 / 8	11.8 / 7.5	3 / 6	5.6 / 8.1	1 / 1	14.3 / 4.0	3 / 1	12.0 / 1.1	0 / 0	0.0 / 0.0
Lower Leg	0 / 0	0.0 / 0.0	1 / 2	1.7 / 6.7	3 / 1	2.5 / 0.9	1 / 2	1.9 / 2.7	0 / 0	0.0 / 0.0	1 / 5	4.0 / 5.3	0 / 0	0.0 / 0.0
Toes	0 / 0	0.0 / 0.0	2 / 2	3.4 / 6.7	4 / 2	3.4 / 1.9	1 / 3	1.9 / 4.1	0 / 1	0.0 / 4.0	0 / 1	0.0 / 1.1	0 / 0	0.0 / 0.0
Hip, Upper Leg, Thigh	0 / 0	0.0 / 0.0	1 / 1	1.7 / 3.3	0 / 0	0.0 / 0.0	1 / 2	1.9 / 2.7	0 / 0	0.0 / 0.0	2 / 4	8.0 / 4.3	0 / 2	0.0 / 20.0
Lower Extremity	**0 / 0**	**0.0 / 0.0**	**17 / 16**	**29.3 / 53.3**	**49 / 37**	**41.2 / 34.9**	**17 / 34**	**31.5 / 45.9**	**2 / 10**	**28.6 / 40.0**	**11 / 31**	**44.0 / 33.0**	**1 / 3**	**100 / 30.0**
Shoulder (incl Clavicle/blade)	0 / 0	0.0 / 0.0	7 / 5	12.1 / 16.7	11 / 9	9.2 / 8.5	4 / 7	7.4 / 9.5	2 / 2	28.6 / 8.0	5 / 14	20.0 / 14.9	0 / 1	0.0 / 10.0
Finger/thumb	0 / 0	0.0 / 0.0	4 / 2	6.9 / 6.7	8 / 5	6.7 / 4.7	8 / 3	14.8 / 4.1	0 / 1	0.0 / 4.0	1 / 4	4.0 / 4.3	0 / 0	0.0 / 0.0
Hand/wrist	0 / 0	0.0 / 0.0	6 / 0	10.3 / 0.0	3 / 3	2.5 / 2.8	3 / 3	5.6 / 4.1	0 / 1	0.0 / 4.0	1 / 0	4.0 / 0.0	0 / 0	0.0 / 0.0
Upper And Lower Arm	0 / 0	0.0 / 0.0	2 / 1	3.4 / 3.3	1 / 2	0.8 / 1.9	0 / 4	0.0 / 5.4	0 / 0	0.0 / 0.0	1 / 1	4.0 / 1.1	0 / 0	0.0 / 0.0
Elbow	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	2 / 0	1.7 / 0.0	0 / 2	0.0 / 2.7	0 / 1	0.0 / 4.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0
Upper Extremity	**0 / 0**	**0.0 / 0.0**	**19 / 8**	**32.8 / 26.7**	**25 / 19**	**21.0 / 17.9**	**15 / 19**	**27.8 / 25.7**	**2 / 5**	**28.6 / 20.0**	**8 / 19**	**32.0 / 20.2**	**0 / 1**	**0.0 / 10.0**
Lower Back/spine	0 / 1	0.0 / 50.0	10 / 2	17.2 / 6.7	18 / 24	15.1 / 22.6	15 / 12	27.8 / 16.2	0 / 4	0.0 / 16.0	4 / 18	16.0 / 19.1	0 / 4	0.0 / 40.0
Neck, Back Of Head Vertebrae	0 / 0	0.0 / 0.0	3 / 1	5.2 / 3.3	10 / 14	8.4 / 13.2	2 / 2	3.7 / 2.7	2 / 1	28.6 / 4.0	1 / 15	4.0 / 16.0	0 / 0	0.0 / 0.0
Upper Back/spine	0 / 1	0.0 / 50.0	4 / 1	6.9 / 3.3	7 / 3	5.9 / 2.8	3 / 2	5.6 / 2.7	1 / 0	14.3 / 0.0	0 / 4	0.0 / 4.3	0 / 0	0.0 / 0.0
Face	0 / 0	0.0 / 0.0	1 / 1	1.7 / 3.3	4 / 2	3.4 / 1.9	2 / 0	3.7 / 0.0	0 / 0	0.0 / 0.0	0 / 1	0.0 / 1.1	0 / 2	0.0 / 20.0
Head (except Face)	0 / 0	0.0 / 0.0	2 / 1	3.4 / 3.3	4 / 3	3.4 / 2.8	0 / 1	0.0 / 1.4	0 / 0	0.0 / 0.0	0 / 1	0.0 / 1.1	0 / 0	0.0 / 0.0
Chest	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	1 / 1	0.8 / 0.9	0 / 0	0.0 / 0.0	0 / 2	0.0 / 8.0	0 / 2	0.0 / 2.1	0 / 0	0.0 / 0.0

Abdomen/pelvis	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 1	0.0 / 0.9	0 / 0	0.0 / 0.0	0 / 2	0.0 / 8.0	0 / 2	0.0 / 2.1	0 / 0	0.0 / 0.0
Ear	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 1	0.0 / 1.4	0 / 0	0.0 / 0.0	1 / 0	4.0 / 0.0	0 / 0	0.0 / 0.0
Nose	0 / 0	0.0 / 0.0	1 / 0	1.7 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 1	0.0 / 1.1	0 / 0	0.0 / 0.0
Eye	0 / 0	0.0 / 0.0	1 / 0	1.7 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0	0 / 0	0.0 / 0.0
Other	**0 / 2**	**0.0 / 100**	**22 / 6**	**37.9 / 20.0**	**44 / 48**	**37.0 / 45.3**	**22 / 18**	**40.7 / 24.3**	**3 / 9**	**42.9 / 36.0**	**6 / 44**	**24.0 / 46.8**	**0 / 6**	**0.0 / 60.0**
Unobtainable	**0 / 0**	**0.0 / 0.0**	**0 / 0**	**0.0 / 0.0**	**1 / 2**	**0.8 / 1.9**	**0 / 3**	**0.0 / 4.1**	**0 / 1**	**0.0 / 4.0**	**0 / 0**	**0.0 / 0.0**	**0 / 0**	**0.0 / 0.0**

a. All costs are inflation adjusted to 2017 values

DISCUSSION

The primary aim of this study was to investigate injuries sustained by surf lifesavers while operating IRBs in New Zealand. The number of injury entitlement claims and associated costs recorded within the ACC database between 2013 and 2017 were analysed. A high rate of lower extremity and soft tissue injuries because of IRB operation were identified. However, there was also a surprisingly high incidence of low back injuries. Risk factors identified included gender and age, with a greater risk of injury for younger females and older males. Landing in the IRB while navigating the surf was reported as the cause of injuries. To the authors knowledge, this is the first surf lifesaving epidemiological study in New Zealand.

Sequence of injury prevention: epidemiology

The "sequence of injury prevention" was outlined by van Mechelen, Hlobil [1] and is commonly used by researchers. The first step is to identify the extent of the surf lifesaving injury problem through epidemiological studies.

Injury site

SLSNZ hypothesised the increase use of IRB*s* in New Zealand coincided with an increase in injuries. Previous research found a high incidence of IRB-related injuries occurring to the lower extremities, particularly the ankle and foot [10, 13, 16]. Similarly, the ankle was consistently one of the most reported injured sites from ACC claims. This is consistent with Fong, Chan [21], whom identified the ankle as the most commonly injured body site in 24/70 sports. However unexpectedly, the most ACC claims and highest incidence of injury were for the lower back, when compared against other specific body sites (e.g. ankle, knee, etc.). This is the first study to quantify IRB-related incidences of lower back injuries in the surf lifesaving population.

Injury type

Epidemiological studies in Australia and the United States identified soft tissue injuries as the leading type of surf lifesaving related injuries. The highest severity injuries however were fractures and dislocations. Ashton and Grujic [16] investigated 12 lower extremity IRB-related fractures reported to hospitals over 3 years in Queensland; 10 of which required surgical repair. ACC results concurred; most injuries were soft tissue sprains and/or strains. Nevertheless, most soft tissue injuries were to the lower back. Conversely, lower back claims totalled less than one fourth of the cost of lower extremity claims, suggesting an increased severity of lower extremity injuries. However, the potential effects of lower back injuries on long term health may also be equally as substantial.

Sequence of injury prevention: risks factors

The second step of the "Sequence of Injury Prevention" was conducted and aimed to identify IRB-related risk factors, establish aetiologies, and understand the mechanisms of injury in order to introduce preventative measures.

Intrinsic

Risk factors can be classified as intrinsic or extrinsic [35]. Intrinsic factors identified relating to IRB-operation include gender, body side, and age. Previous literature identified older age as a significant risk factor of injury, yet gender was not significantly related [13, 15]. However, both studies included injuries from all surf lifesaving activities. Furthermore, Mitchell, Brighton [13] demonstrated this relationship only during training, and Jackson [15] reported the relationship as the age at the time of survey completion, rather than the age at time of injury. ACC results identified a relationship between age at the time of incident and IRB-related injury, however, the relationship was also dependent upon gender. Younger females and older males had a higher incidence of injury, suggesting, surf lifesavers operating IRB*s* could benefit from age- and gender- specific injury prevention strategies.

Extrinsic

Extrinsic risk factors may explain the correlation between crew position and injury risk. Multiple studies have identified an increased risk of injury to surf lifesavers operating IRBs compared to other surf lifesaving tasks [10, 13] in addition to the recognised impact of IRB equipment on crew member biomechanics [17]. Moreover, the foot straps inside the IRB were previously found to be directly related to lower extremity injuries [16]. However, equipment related injuries were substantially less common than landing injuries from ACC findings. Nevertheless, females demonstrated twice a greater risk of injury than males due to the foot strap. Therefore, mechanisms of IRB-related injury may vary based on gender.

Surf lifesaving is heavily contingent on the weather and water conditions [12]. Other water-based board sports have identified weather conditions as a leading cause of injury. Similar to ACC and questionnaire results, kitesurfing, windsurfing, and traditional surfing demonstrated high incidences of lower extremity and lower back soft tissue injuries occurring during airborne landings [24-28]. However, no studies have investigated the effects of weather and water conditions on similar injuries occurring in IRBs. Therefore, future research should examine the effects of weather and water conditions on the mechanisms of lower extremity and lower back injuries during IRB operation.

Ludcke [17] found an interdependency between surf conditions, IRB equipment, and loads (e.g. accelerations) experienced by surf lifesavers. The New Zealand summer of 2016 - 2017 was reported to have particularly bad weather. Interestingly, in the 2016 - 2017 season, there were no injury claims due to the crew member foot strap, but an increase in landing and ejection-related injuries. The increase in mechanistic injuries combined with poor weather conditions may demonstrate an inability of the crew members to stay firmly inside the boat without the security of both the left and right foot straps. This is supported by ACC findings; the 16 -20 age group accounted for the greatest number of *MSC* claims; however, the older male population had the greatest incidence of injury. Injuries to sports participants over 30 years of age can present a unique challenge to the sports medicine community. There is a lack of knowledge detailing the incidences of injuries specifically related to this age population participation, thus supporting a need for future research to identify population-specific risks and injury incidence [36]. Therefore, weather conditions may pose age-specific risk factors causing varying mechanisms of IRB-related injuries.

Sequence of injury prevention: cause and mechanism

Understanding injury mechanisms is a key component of preventing injuries in sports and a full description for each particular injury is necessary. Bahr [37] suggested grouping the injury mechanism into four categories: situation, qualitative description of the athletes' action, description of the whole body biomechanics, and a detailed description of the joint and tissue biomechanics [37]. Researchers have attempted to understand the mechanism of surf lifesaving injuries through computer simulation and pilot quantitative studies [14, 19]. However, these studies are outdated and only reference ankle and foot injuries. Therefore, a full understanding of IRB-related injury mechanisms is necessary to introduce preventative measures.

Situation and behaviour

Mitchell, Brighton [13] and Bigby, McClure [10] reported the most IRB injuries occurred while navigating the surf and negotiating the break. Navigating a wave was one of the main causes of injuries reported to ACC. Nevertheless, landing after being airborne was the lead cause of injury. Moreover, the most reported cause of both lower back and lower extremity injuries was due to landing in the IRB, rather than previously expected equipment related. This is the first study to report this finding among the surf lifesaving population.

Females demonstrate an increased risk of injury during landing behaviours [38]. In agreement, female surf lifesavers in New Zealand demonstrated a high incidence of landing-related lower extremity and lower back injuries. It may be beneficial to reference female-specific landing literature

in other sports in order to gain a better understanding of the mechanisms of injury occurring to female surf lifesavers.

Whole body and joint biomechanics

The lower extremities may be unable to handle the excessive dynamic loads during landing [27]. Females are predisposed to an increased risk of injury due to poor landing mechanics, demonstrating significantly reduced hip abduction and external rotation isometric strength, as well as side bridge endurance [38]. Weaknesses in these areas may increase female vulnerability to large external forces, and as a result, females may be predisposed to excessive motion in the hip or trunk permitting their lower extremity to move into compromised positions [39]. ACC results showed increased or comparable soft tissue injury incidences in females at the knee, ankle, foot, hip, and lower back. Thus, a complete description of the mechanisms for each joint needs to be examined in detail.

Decreased core stability is a known risk factor of lower back pain. A large component of core stability is muscle endurance in the lumbo-pelvic-hip complex. The endurance of the trunk extensors and isometric hip strength has been found to predict the occurrence of lower back pain in 30 - 60 year old adults [39]. Females have demonstrated significantly reduced hip abduction and external rotation isometric strength, as well as side bridge endurance [38]. Weaknesses in core stability may predispose females to lower back pain. Furthermore, the hip muscles help to control rotational alignments of the lower limbs and maintain pelvic stability during a single leg stance [40]. Thus, hip muscle weakness may also contribute to lower back pain due to abnormal segmental movement of the lumbar spine if the pelvis is not stable during operation of the IRBs. The greatest incidence of lower back claims was reported by females aged 21 - 30, mainly due to landing. The increase in younger female lower back injury incidences may be due to a lack of core stability, specifically hip strength and endurance.

The ankle was the second most reported injured site from ACC findings; the majority being soft tissue sprains or strains. Traumatic ligament sprains of the ankle joint are the most common injuries at every level of sports and comprise about 14% of all sport-related injuries. Among all ligament sprain injuries, roughly 80% are lateral ankle sprains [22]. Therefore, it may be beneficial to compare IRB-related ankle injuries with mechanisms of lateral ankle sprains common in other sports.

ACC results are consistent with the most common cause of ankle sprain; foot positioning during touchdown. When a foot is plantarflexed during touchdown, the contact to the ground is made with the forefoot, increasing the moment arm about the subtalar joint axis and also the resultant joint torque to cause sudden explosive twisting motion and thus, ankle sprain injury [21]. Researchers have demonstrated that people suffering from lumbar fatigue will respond differently to ground reaction forces [41]. In fatigued conditions, such as during repetitive IRB operation, surf lifesavers may experience less vertical ground reaction forces during landing, due to an adopted “toe-heel” or fore-foot landing approach [42], increasing the risk of an inversion ankle sprain.

The second common cause of lateral ankle sprain injuries is the delayed peroneal reaction time upon landing [21]. Reaction time is affected by fatigue. Moreover, sudden loads can exacerbate fatigue effects [42], such as that occurring during repetitive navigation of waves in an IRB. Therefore, females operating IRBs are at an increased risk of lateral ankle sprain due to a forefoot landing approach and delayed reaction time, further exacerbated by the impaired reflex latencies due to lumbo-pelvic-hip fatigue.

The “toe-heel” landing approach may also explain the increased incidence of injuries to females at other lower extremity joints (e.g. knee, hip). The landing technique results in a “softer” landing as the knee and hip tend to absorb more of the ground reaction forces. Females have demonstrated lower hip abduction and increased knee valgus when landing from a jump [38]. Medial collapse of the lower extremity during weight-bearing activity, described as adduction and internal rotation of the femur accompanied by knee valgus, tibia internal rotation, and increased foot pronation, might be related to hip-strength imbalance in the frontal plane [30]. Studies have shown that reduced isometric strength of the hip abductors relative to the hip adductors is associated with increased pronation at the foot. Correlations between hip abductor strength and landing kinematics were found to be larger

for females than males, suggesting hip abductor strength may play a more important role in the neuromuscular control of the knee for females [38]. Female surf lifesavers may be at an increased risk of acute knee injury [38] during IRB operation due to a lack of hip (trunk) strength.

The activity of superficial trunk muscles is impaired in patients with lower back pain during dynamic tasks over unstable surfaces [43]. The hip (trunk) muscles are tightly coupled with the lumbar paraspinal muscles via the thoracolumbar fascia, which allows the load transfer from the lumbar spine to the lower extremities [40]. The high number of lower back injuries sustained by surf lifesavers may be closely related to the high number of ankle and other lower extremity injuries. Research has shown the single best predictor of future lower back pain is a history of lower back pain [44]. Chronic lower back pain may effect landing techniques in fatigued states, therefore increasing the possibility of ankle and other lower extremity injuries.

Literature has shown that 74% of patients whom suffered from an inversion ankle sprain injury had persisting symptoms 1.5 - 4 years after, in which 10 - 30% may have had chronic symptoms, such as persistent synovitis or tendinitis, muscle weakness, and frequent giving-way [21]. This suggests an increased risk of developing persistent injury symptoms due to IRB operation.

Sequence of injury prevention: prevention strategies

To address the potential effectiveness of injury prevention strategies, injury mechanisms must be considered in relation to intrinsic and extrinsic risk factors. Younger females seem to be at an increased risk of IRB-related injury due to do a lack of trunk strength. Although no strength interventions have been assessed for effectiveness in surf lifesavers, researchers in other athletic populations have recommended female athletes focus on improving proper landing technique, as well as core and hip strength [27]. Therefore, surf lifesavers operating IRBs could benefit from age- and gender- specific technique and strength training interventions to increase hip and trunk musculature strength and endurance.

Equipment related risk factors may also be modifiable in order to reduce injury occurrence. Biomechanical limitations have been shown to be highly variable and dependent on the crew member foot strap positions and angles [17]. Female anthropometrics may place crew members in a biomechanically disadvantageous position. Therefore, modifications to IRB equipment to accommodate gender-specific anthropometrics may reduce the incidence of female surf lifesaving injuries.

With recent IRB regulation changes, and recognised impact of equipment on IRB operation and crew member biomechanics [17], future studies should focus on identifying current equipment standards of clubs in New Zealand.

Limitations

The main finding of this study was the high incidence of lower back and lower extremity injuries. The nature of chronic injuries; occurring over a period of time due to repetitive movements, with no identifiable inciting event, likely adds to the underestimation of injury and long-term impact of surf lifesaving participation.

The difficulty in identifying the true extent of surf lifesaving injuries is there is no single universally accepted definition of injury. Furthermore, ACC data collection does not specify the difference between “surf” or “surf lifesaving” injuries, thus, free text analysis was the best method of identifying occurrences. Therefore, there are several limitations that should be considered when interpreting the ACC data presented here.

The population data used to determine incidence rates can only provide an estimate of the number of surf lifesavers who used IRB*s* during the study period. Furthermore, the duration of use was unobtainable and not all certified lifesavers operate IRB*s*. Nevertheless, the population included every surf lifesaver with a Surf Lifeguard Award (or refresher). Thus, it is likely that the incidence of injury reported is a severe underestimate.

All ACC injuries recorded in this study required additional assistance beyond medical treatment alone [32]. Therefore, the numbers reported are not a reflection of how many surf lifesaving injuries were occurring, but how many injuries were recorded by individuals. The results of this study could be biased as they exclude those individuals that do not lodge an ACC injury entitlement form for a surf lifesaving injury that they dealt with themselves. Moreover, databases on ocean lifeguard injuries are scarce and the available injury data likely underestimates the prevalence of musculoskeletal injuries in this population [12].

CONCLUSIONS

This study reports the number of ACC claims lodged, and the associated costs of surf lifesaving IRB-related injuries that occurred in New Zealand over a five-year period. The incidence of surf lifesaving IRB reported injuries for the 2013 to 2017 was 103 per 1,000 estimated members resulting in average of 0.41 total IRB-related claims lodged for surf lifesaving per-day. Lower extremity and lower back injuries made up most claims, most of which occurred during landing inside the IRB. Future research and injury prevention strategies should target ways to minimise the number and effects of landings.

COMPETING INTERESTS

The authors declare that there are no competing interests associated with the research contained within this manuscript.

FUNDING

Funding was provided for a research assistant by AUT and Surf Life Saving New Zealand to help conduct this study.

CONTRIBUTORS STATEMENT

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. According to the definition given by the International Committee of Medical Journal Editors (ICMJE), the authors listed above qualify for authorship based on making one or more of the substantial contributions to the intellectual content of:

(i) Conception and design [SD; PH; KM]; and/or,
(ii) Acquisition of data [KM; DK; PH]; and/or
(iii) Analysis and interpretation of data [SD, PH, KM, AW, RM, BW]; and/or
(iv) Participated in drafting of the manuscript [SD, PH, KM, AW, RM, BW]; and/or
(v) Critical revision of the manuscript for important intellectual content [SD, PH, KM, AW, RM, BW].

REFERENCES

1. van Mechelen, W., H. Hlobil, and H. Kemper C.G., *Incidence, Severity, Aetiology and Prevention of Sports Injuries: A Review of Concepts.* Sports Medicine, 1992. **14**(2): p. 18.
2. Moran, K. and J. Webber, *Surfing Injuries Requiring First Aid in New Zealand, 2007-2012.* International Journal of Aquatic Research and Education, 2013. **7**(3).
3. Moran, K. and J. Webber, Leisure-related injuries at the beach: an analysis of lifeguard incident report forms in New Zealand, 2007-12. Int J Inj Contr Saf Promot, 2014. **21**(1): p. 68-74.
4. *Inflatable Rescue Boat Training Manual*. 2018, SLSNZ: PO BOX 9205. p. 1-71.
5. Dalton, P., *Serious Injury Report 2013-14 Season*. 2014, SLSNZ. p. 1-5.
6. Dalton, P., *Serious Injury Report 2017-18 Season*. 2018, SLSNZ. p. 1-6.
7. Dalton, P., *Serious Injury Report 2016-17 Season*. 2017, SLSNZ. p. 1-7.
8. Dalton, P., *Serious Injury Report 2015-16 Season*. 2016, SLSNZ. p. 1-7.
9. Dalton, P., Serious Injury Report 2014 - 15 Season. 2015, SLSNZ. p. 1-8.
10. Bigby, K.J., R.J. McClure, and A.C. Green, *The incidence of inflatable rescue boat injuries in Queensland surf lifesavers.* Medical Journal of Australia, 2000. **172**(10): p. 4.
11. Ryan, K.M., et al., Injuries and exposures among ocean safety providers: A review of workplace injuries and exposures from 2007-2012. J Occup Environ Hyg, 2017. **14**(7): p. 534-539.
12. Erby, R., R. Heard, and K. O'Loughlin, *Trial of an injury reporting system for surf lifesavers in Australia.* Work, 2010. **36**(2): p. 181-92.
13. Mitchell, R., B. Brighton, and S. Sherker, *The epidemiology of competition and training-based surf sport-related injury in Australia, 2003–2011.* Journal of Science and Medicine in Sport, 2013. **16**(1): p. 18-21.
14. Yorkston, E., et al., Inflatable rescue boat-related injuries in Queensland surf lifesavers: the epidemiology - biomechanics interface. Int J Inj Contr Saf Promot, 2005. **12**(1): p. 39-44.
15. Jackson, R.A., *Musculoskeletal Injuries in California Ocean Lifeguards*, in *Department of Kinesiology*. 2017, California State University: ProQuest LLC. p. 58.
16. Ashton, A.L. and L. Grujic, Foot and ankle injuries occurring in inflatable resuce boats (IRB) during surf lifesaving activities. Journal of Orthopaedic Surgery, 2001. **9**(1): p. 5.
17. Ludcke, J.A., Modelling of Inflatable Rescue Boats (IRB*s*) in Surf Conditions to Reduce Injuries, in School of Mechanical, Manufacturing and Medical Engineering. 2001, Queensland University of Technology. p. 263.
18. Corbett, B., M. Thompson, and R. Budd, *Board of Lifesaving - Minutes:* IRB *Review*. 2010. p. 1-38.
19. Ludcke, J.A., et al., *Impact data for the investigation of injuries in inflatable resuce boats (*IRB*s).* Australasian Physical and Engineering Sciences in Medicine, 2001. **24**(2): p. 7.
20. Chu, V.W.-S., et al., Differentiation of ankle sprain motion and common sporting motion by ankle inversion velocity. Journal of Biomechanics, 2010. **43**(10): p. 2035-2038.
21. Fong, D.T., et al., *Understanding acute ankle ligamentous sprain injury in sports.* Sports Med Arthrosc Rehabil Ther Technol, 2009. **1**: p. 14.
22. Purevsuren, T., et al., Influence of ankle joint plantarflexion and dorsiflexion on lateral ankle sprain: A computational study. Proc Inst Mech Eng H, 2018. **232**(5): p. 458-467.
23. Mundy, A., Operational Memo 3: Compulsory removal of the right foot strap in IRBs', S.L.S.N. Zealand, Editor. 2017. p. 7.
24. Bergen, C.v., et al., Windsurfing vs kitesurfing: Injuries at the North Sea over a 2-year period. World Journal of Orthopedics, 2016. **7**(12).
25. Dyson, R., M. Buchanan, and T. Hale, *Incidence of sports injuries in elite competitive and recreational windsurfers.* Br J Sports Med, 2006. **40**(4): p. 346-50.
26. Lundgren, L., et al., *High ankle sprain: The new elite surfing injury?* International Sport Medicine Journal, 2014. **15**: p. 7.
27. Lundgren, L.E., et al., Comparison of impact forces, accelerations and ankle range of motion in surfing-related landing tasks. Journal of Sports Sciences, 2015. **34**(11): p. 1051-1057.

28. Silva, B., et al., Injuries among Portuguese kitesurfers: The most affected body regions A pilot study. Motricidade, 2016. **11**(4).
29. Vormittag, K., R. Calonje, and W.W. Briner, *Foot and Ankle Injuries in the Barefoot Sports.* Current Sports Medicine Reports, 2009. **8**(5): p. 5.
30. Hollman, J.H., et al., Correlations Between Hip Strength and Static Foot and Knee Posture. J Sport Rehabil, 2006. **15**: p. 13.
31. Scott F. Nadler, G.A.M., Melissa DePrince, Todd P. Stitik, and Joseph H. Feinberg, *The Relationship Between Lower Extremity Injury, Low Back Pain, and Hip Muscle Strength in Male and Female Collegiate Athletes.* Clinical Journal of Sport Medicine, 2000. **10**(2): p. 9.
32. Gianotti, S. and P. Hume, Concussion sideline management intervention for rugby union leads to reduced concussion entitlement claims. NeuroRehabalitation, 2007. **22**(3): p. 181-189.
33. Gianotti, S. and P. Hume, A cost-outcome approach to pre and post-implementation of national sports injury prevention programmes. J Sci Med Sport 2007. **10**(6): p. 436-446.
34. King, D., et al., Rugby league injuries in New Zealand: Variations in injury claims and costs by ethnicity, gender, age, district, body site, injury type and occupation. NZ J Sports Med 2009. **36**(2): p. 48-55.
35. Chan, K.M., et al., *Orthopaedic sport biomechanics - a new paradigm.* Clin Biomech (Bristol, Avon), 2008. **23 Suppl 1**: p. S21-30.
36. King, D., et al., Sports-related injuries in New Zealand: National Insurance (Accident Compensation Corporation) claims for five sporting codes from 2012 to 2016. British Journal of Sports Medicine, 2018.
37. Bahr, R., Understanding injury mechanisms: a key component of preventing injuries in sport. British Journal of Sports Medicine, 2005. **39**(6): p. 324-329.
38. Jacobs, C.A., et al., Hip Abductor Function and Lower Extremity Landing Kinematics: Sex Differences. Journal of Athletic Training, 2007. **42**(1): p. 9.
39. Leetun, D.T., et al., *Core Stability Measures as Risk Factors for Lower Extremity Injury in Athletes.* Medicine & Science in Sports & Exercise, 2004. **36**(6): p. 926-934.
40. Sousa, C.S.d., et al., Lower limb muscle strength in patients with low back pain: a systematic review and meta-analysis. J Musculoskelet Neuronal Interact, 2019. **19**(1): p. 10.
41. Radebold, A., et al., Muscle Response Pattern to Sudden Trunk Loading in Healthy Individuals and in Patients with Chronic Low Back Pain. SPINE, 2000. **25**(8): p. 8.
42. Jalalvand, A. and M. Anbarian, Effect of Lower Limb Muscle Fatigue on Ground Reaction Force Components During Landing in People With Nonspecific Chronic Low Back Pain. J Sport Rehabil, 2019: p. 1-7.
43. Ehsania, F., A.M. Arabb, and S. Jaberzadehc, The effect of surface instability on the differential activation of muscle activity in low back pain patients as compared to healthy individuals: A systematic review of the literature and meta-analysis. Journal of Back and Musculoskeletal Rehabiliation, 2017. **30**: p. 15.
44. Cholewicki, J., et al., Delayed Trunk Muscle Reflex Responses Increase the Risk of Low Back Injuries. Spine, 2005. **30**(23): p. 7.