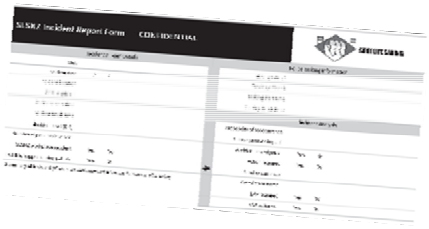
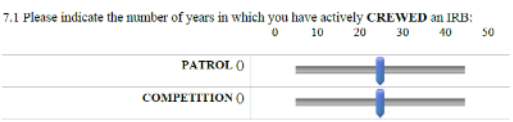
An overview of the issues for recreational and competitive surf lifesaving injuries associated with inflatable rescue boats: Technical report #6 to Surf Life Saving New Zealand (SLSNZ)





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

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

[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

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SLSNZ research programme team
Professor Patria Hume – AUT SPRINZ, Professor Human Performance
Professor Barry Wilson – AUT SPRINZ, Professor Biomechanics
Associate Professor Stephen Reay – AUT Good Health Design, Associate Professor Design
Dr Valance Smith – AUT Associate Pro Vice Chancellor Maori
Miss Shelley Diewald – AUT SPRINZ, Engineering Research Officer
Mr Michael Grobleny – AUT Good Health Design, Research Officer
Dr Lisa Keeley – AUT SPRINZ, Technician
Mr Kieran McMinn – AUT SPRINZ, Research Intern
Mr Ross Merrett – SLSNZ, Health, Safety, Welfare, and Risk Manager
Mr Adam Wooler – SLSNZ, CFO
Ms Kirsten Malpas – ACC, Injury Prevention Manager
Mr David Hickey – SLSNZ, National Powercraft Officer
Mr Allan Mundy – SLSNZ, National Lifesaving Manager
Mr John Speight – Arancia, Company owner and boat designer
Miss Renata Bastos Gottgtroy – AUT SPRINZ, Research Officer

OVERVIEW OF PHASE I AND RECOMMENDATION FOR PHASE II OF THE SLSNZ RESEARCH PROGRAMME

This overview report summarises via fact sheets, the key injury issues for NZ surf lifesavers based on a literature review (report #1) and analyses of injury data derived from the SLSNZ database (report #2), a SLSNZ member survey (report #3), and ACC data (report #4). We also conducted the feasibility of a measurement system for accelerations and movement patterns during on-the-water lifesaving activity. The phase I cost was SLSNZ $10k and AUT Research and Innovation Office $10k. Details of the methods, findings, conclusions and recommendation are available in the reports:

Diewald, S., Hume, P. A., Wilson, B. D., Wooler, A., Merrett, R., Fong, D. P., . . . Smith, V. (2019). *Recreational and competitive surf lifesaving injuries associated with inflatable rescue boats derived from a systematic literature review: Technical report #1 to Surf Life Saving New Zealand (SLSNZ)*. Auckland, New Zealand: Auckland University of Technology. [1]

Diewald, S., Hume, P. A., Wilson, B. D., Wooler, A., Merrett, R., Fong, D. P., . . . Smith, V. (2019). *Surf Lifesaving Injuries in New Zealand between 2009 to 2018 derived from the Surf Life Saving New Zealand Injury Reporting Database: Technical Report #2 to Surf Life Saving New Zealand (SLSNZ)*. Auckland, New Zealand: Auckland University of Technology. [2]

Diewald, S., Hume, P. A., Wilson, B. D., Wooler, A., Merrett, R., Fong, D. P., . . . Smith, V. (2019). *Recreational and competitive surf lifesaving injuries associated with inflatable rescue boats derived from an online survey of members: Technical report #3 to Surf Life Saving New Zealand (SLSNZ)*. Auckland, New Zealand: Auckland University of Technology. [3]

Diewald, S., Hume, P. A., Malpas, K., Wilson, B. D., Wooler, A., Merrett, R., . . . Smith, V. (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)*. Auckland, New Zealand: Auckland University of Technology. [4]

Diewald, S., Hume, P. A., Wilson, B. D., Wooler, A., Merrett, R., Grobleny, M., . . . Smith, V. (2019). *Boat instrumentation feasibility study to assess biomechanics of competitive surf lifesavers during inflatable rescue boat activities: Technical Report #5 to Surf Life Saving New Zealand (SLSNZ)*. Auckland, New Zealand: Auckland University of Technology. [5]

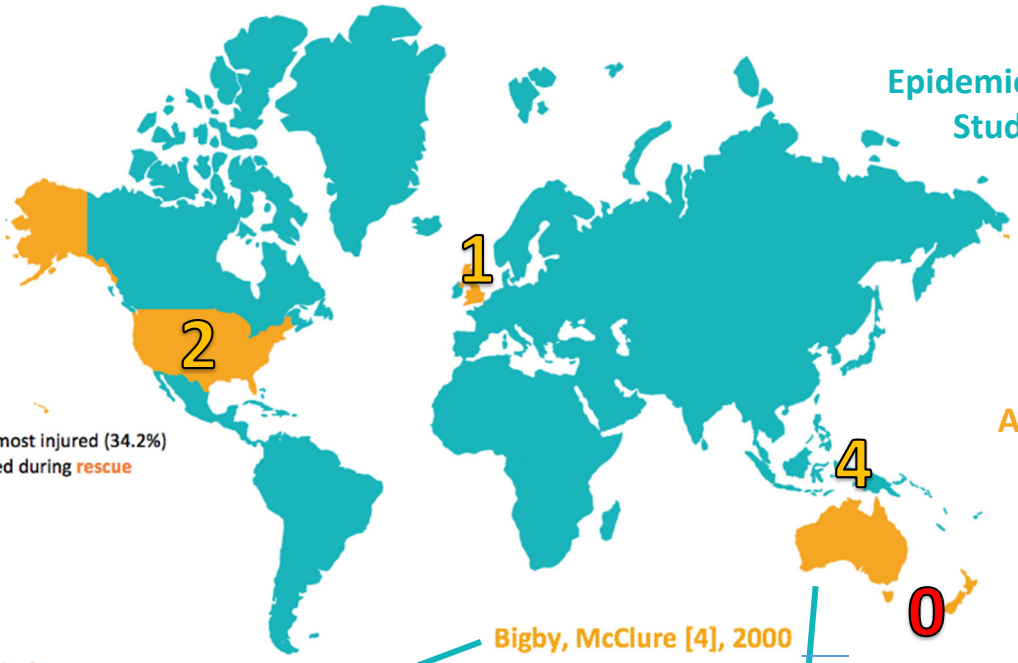
SLSNZ has allocated $50k for phase II. An AUT FHES grant was submitted for $20k, however due to the highly contestable nature of the grants and limited funds, the application was unfortunately not successful. Given consideration of the phase I findings during a workshop to review reports 1-5 held 18th June at AUT's SPRINZ, Phase 2 options were discussed then prioritized:

1. **Map of injuries** to outline the extent, system and stories (Shelley Diewald, Ross Merrett, Adam Wooler, Barry Wilson). *(~ $2,000).*
2. **Injury and participation reporting system improvements** (Shelley Diewald, Ross Merrett, Adam Wooler, Barry Wilson). *(~ $2,000).*
3. **Occupational fitness standards**. (Kieran McMinn, Renata Bastos Gottgtroy, Ross Merrett, Adam Wooler, Barry Wilson, Patria Hume). *(~ $5,000 + student experience time).*
4. **Loads in heavy surf** and **standardised movements in the IRB** (Shelley Diewald, Kieran McMinn, Renata Bastos Gottgtroy, Barry Wilson, Patria Hume, Shane Edwards) using a biomechanics approach (~ *$20,000 + student experience time).*
5. **Boat design changes** (Stephen Reay, Michael Groblney, John Speight, Barry Wilson, Patria Hume, Renata Bastos Gottgtroy) using a combined design and biomechanics approach *(~ $20,000).*
6. **ACC/KAB cultural value changes for preservation of self** (Ross Merrett, Kirsten Malpas, Stephen Reay, Valance Smith, Patria Hume, Innovation team, WorkSafeNZ,) (~ *$10,000).*
7. **Reporting technologies and communication plan** (Ross Merrett, Adam Wooler, Stephen Reay, Kirsten Malpas, Valance Smith) (~ *$10,000).*

Recommendations

1. Develop a communication plan to provide key messages from the fact sheets to SLSNZ members.
2. Provide the fact sheets on the SLSNZ website to show the "why" to the SLSNZ membership.
3. Start telling stories that are based on research facts.
4. Use leadership roles models to influence using social media.
5. Run brainstorming sessions with SLSNZ members to gain ideas for solutions to the issues identified in the projects.
6. Co-design interventions with user groups.
7. Develop initiatives to address the gender equity issue.
8. Discuss the phase II priority list, budget and Gant chart to confirmed what comprise phase II.

Injuries during surf lifesaving in inflatable rescue boats: evidence from international literature - Fact Sheet



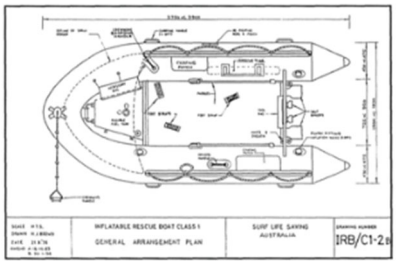
Epidemiological Studies

Lower extremity most injured (34.2%)
35.5% occurred during rescue

Australian Surf Life Saving Research

Causes of Injury

- Poor Conditions
- Inexperience
- Inappropriate Operation
- Lack of Fitness



Bigby, McClure [4], 2000

Of 36 injuries, 22 (61%) occurred to right side of the body, with 68% of those occurring to the lower limb (knee, leg, ankle)

Ashton and Grujic [3], 2001

11/12 Foot Fractures due to right foot strap

Ludcke [25], 2001

Yorkston, Arthur [1], 2005

Accelerations similar to motor vehicle accident

Variation across Australia in foot strap stance width, distance, and design

Counterintuitive findings, with more force on the left foot strap, where previous research suggested greater injuries occur to the right limb.
Limitation: many participants did NOT use the right foot strap (modification to technique)

Mitchell, Brighton [2], 2013

Sprains and strains, bruising/contusion, inflammation/swelling, fractures, and dislocations were the most common type of injuries experienced during both competition and training for IRB events.

KEY FINDINGS

- **No published studies for New Zealand surf lifesaving injuries**
- **High incidence of lower extremity injuries to right limb of crew members; consistent with potential issue due to foot strap**
- **Only 3 studies measured forces and accelerations experienced during IRB operation and set-up**

ABSTRACT – #1 LITERATURE REVIEW

Background: Injuries to surf lifesavers operating inflatable rescue boats was identified as a problem by Surf Life Saving New Zealand (SLSNZ). However, the extent and nature of the injuries was not clear from internal SLSNZ reports.

Purpose: To examine effects of factors influencing injury related to surf lifesavers operating inflatable rescue boats and to determine priorities for countermeasure interventions. It was hypothesised that susceptibility and risk of different injuries may vary between patrol duties and competition use of IRB, and between crew and driver.

Methods: The systematic review of international published literature and screening process resulted in 26 articles published from 1971 to 2018 that met the inclusion and exclusion criteria. Epidemiological studies that examined surf lifesaving or water board-sport related injuries were included. SLSNZ provided internal injury reports from 2013-2017, along with the SLSNZ Inflatable Rescue Boat Manual and SLSNZ board meeting minutes.

Results: There was a high incidence of lower limb injuries resulting from inflatable rescue boat operation according to the limited research. Navigating the surf and landing after aerial movements were frequent causes of injury. Susceptibility and risk to different injuries varied between patrol and competition forms of IRB use and between crew members and drivers.

Discussion: Variation in methodological design made it difficult to compare international results. Potential injury risk factors include equipment design, driver experience, and crew technique, strength and experience, maturity and attitude of drivers.

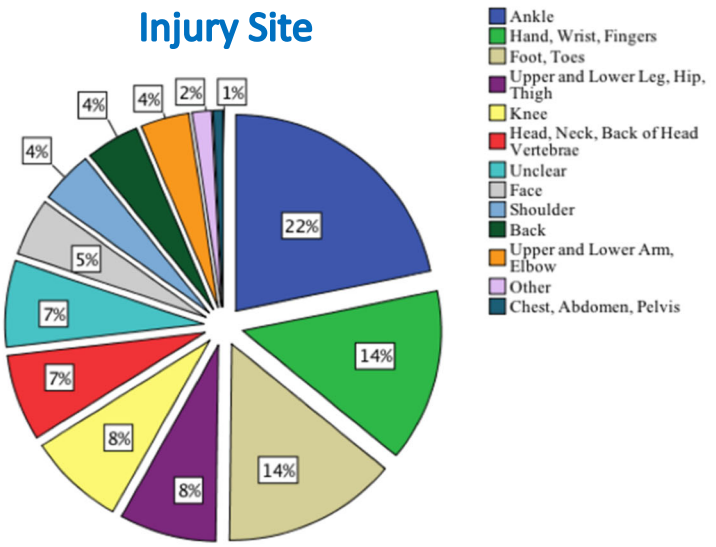
Conclusions: Susceptibility and risk to injuries varied between patrol and competition forms of IRB use and between crew members and drivers. Key risk factors identified from the studies included position in the IRB (crew or driver), lower body strength, and IRB equipment design.

Recommendations:

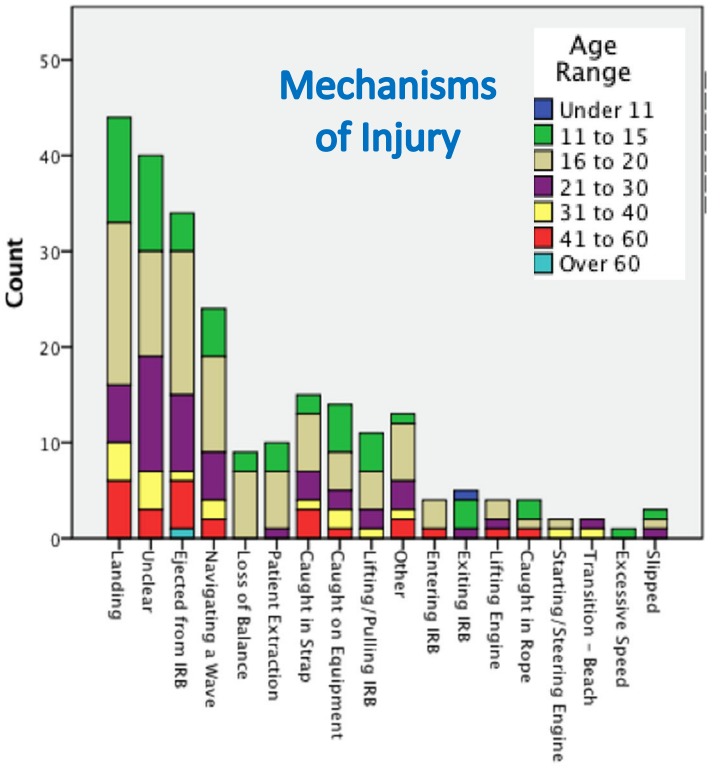
1. Future injury recordings and studies should focus on investigating occurrence of acute and chronic lower back injuries, as well as presenting a prevention strategy and training program to increase strength in the lower limbs, trunk, and hip musculature.
2. Further research is warranted to quantify injury incidence rates in surf lifesaving and deduce injury mechanisms.

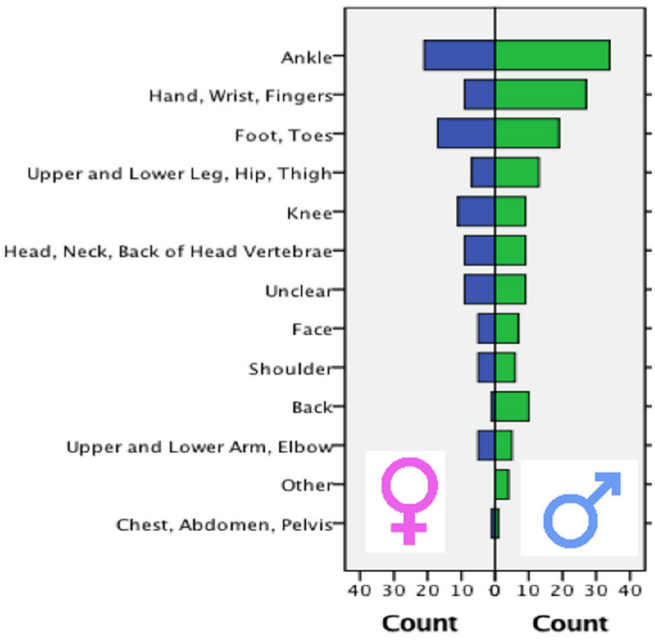
Surf Life Saving New Zealand injury reporting database - Fact Sheet

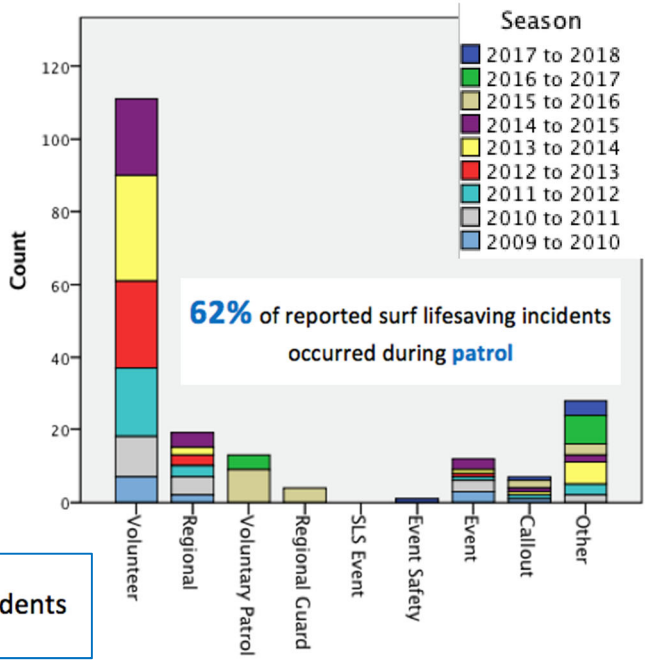
Injury Site



Mechanisms of Injury







Injury Type was **not** reported in **34%** of IRB-related incidents

Key Findings

- **From 2009 to 2018, there was an average 28 IRB-related incidents reported each season**
- **Lower extremity injuries were most frequent (131/253, 51.8%)**
- **SLSNZ should modify the current injury reporting form to include injury site, injury type and mechanism of injury, and remove unnecessary fields to ensure relevant information**

Diewald S.N., Hume P.A. et al. (2019). An overview of the issues for recreational and competitive surf lifesaving injuries associated with inflatable rescue boats: Technical report #6 to Surf Life Saving New Zealand (SLSNZ).

ABSTRACT – #2 SLSNZ DATABASE OF INJURIES

Background: Incident Report Forms (IRFs) are routinely completed by lifeguard patrols and include all incidents attended to by lifeguards in their supervision of beaches including rescue, search, and first aid activity. According to SLSNZ internal injury reports, increased use of IRBs in New Zealand may have resulted in an increase in injury incidences. However, the details surrounding these injuries were not provided in the internal reports.

Purpose: To analyse the SLSNZ database from 2009 to 2018 to identify injury sites, types, and mechanisms of IRB-related injuries occurring to surf life savers and reported to SLSNZ.

Methods: A retrospective analysis of the SLSNZ injury database for 2009 to 2018 was conducted.

Results: In total, there were 253 (female: 100/253, 39.5%; male: 153/253, 60.5%) IRB-related injury cases reported to SLSNZ from 2009 to 2018. More reported surf lifesaving incidents occurred during patrol (155/253) than competition (12/253). Overall, most injuries to surf lifesavers were lower extremity injuries (131/253, 51.8%). The most reported injury types from 2009 to 2018 were "unclear" (86/253, 34.0%) followed by lacerations (65/253, 25.7%). Overall, the most reported injury mechanism from treatment note free text analysis was "landing" (females: 21/100, 21.0%; males: 25/153, 16.3%) defined by the authors as "landing inside the IRB after going airborne while the IRB was in the water".

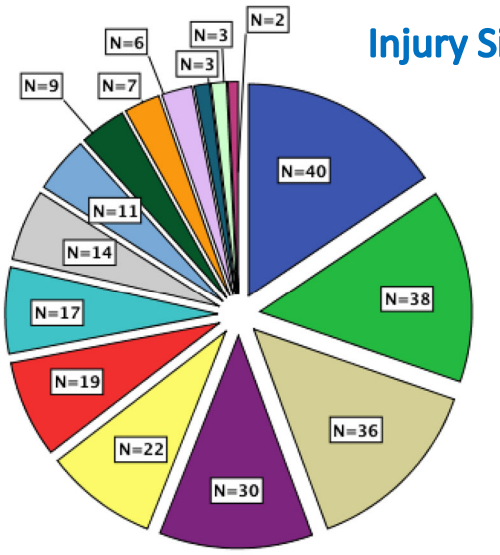
Discussion: Injury prevention initiatives should be focused on areas of high injury frequency such as the landings after becoming airborne. The mechanisms for the lower extremity injuries needs to be clearly identified. As lacerations were most frequent the first aid kits will need adequate supplies such as steristrips. Staff first aid training should focus on lower limb fracture, ankle sprain, and laceration, first response treatment. SLSNZ would benefit from investigating the reporting rates of surf life savers and member mindset surrounding incident reporting, particularly in cases involving IRBs, as there was clear underreporting of injuries given feedback from SLSNZ staff on the results in this report.

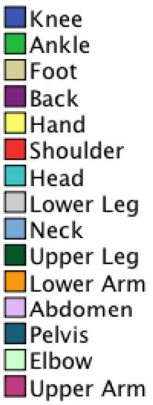
Conclusions: The SLSNZ injury database likely provides an underestimation of the number of injuries resulting from the use of IRBs during patrol and competition. Lower limb and back injuries were frequent. Landing after becoming airborne while the IRB was in the water was a common cause of injury.

Recommendations:

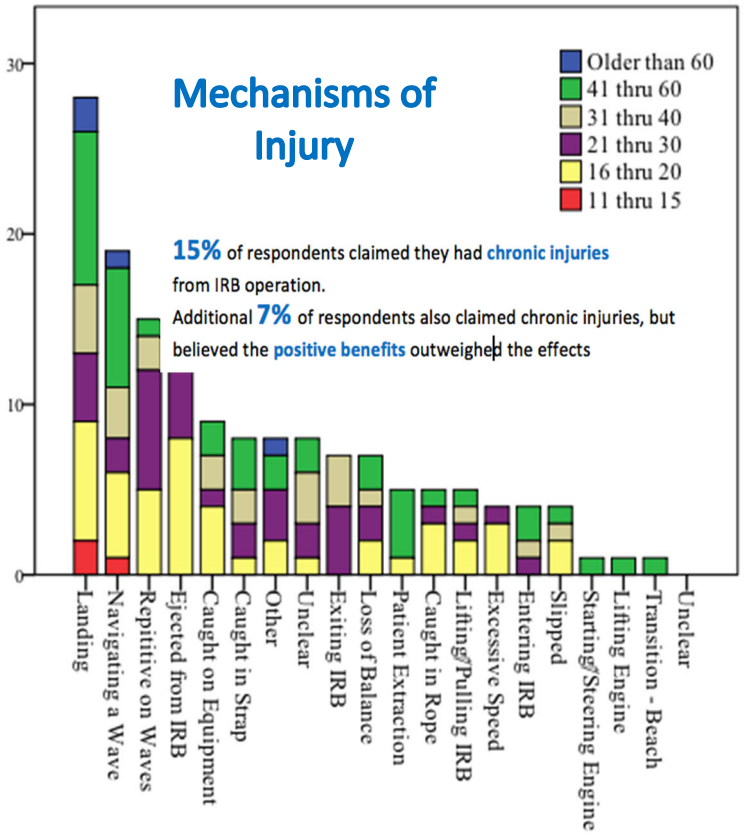
1. Provide fact sheets with key information on injury numbers and risk factors to show why data collection is important and how it is useful for SLSNZ to help inform decisions on injury prevention strategies.

Surf Life Saving New Zealand Members' Questionnaire - Fact Sheet





Total number of respondents reporting at least one sustained injury (out of 196)

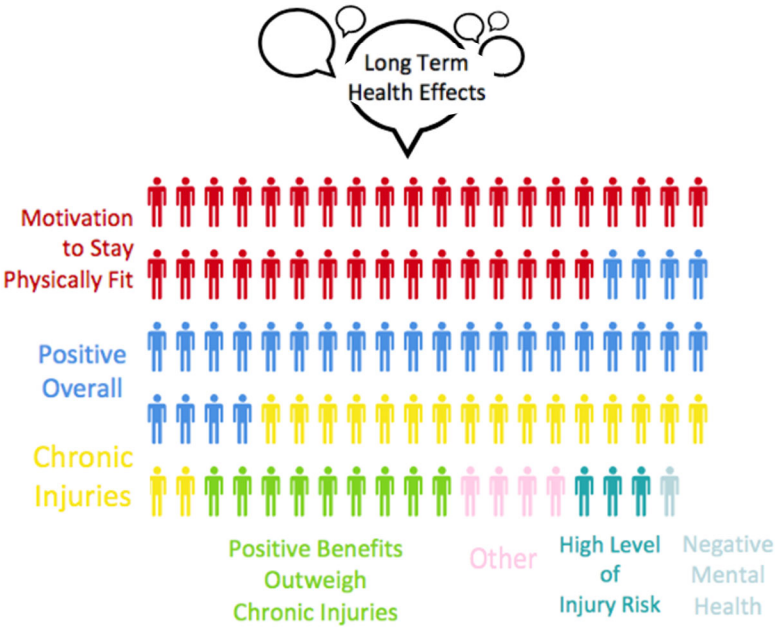


Respondent Demographics

♀ 36% N=196 ♂ 63%

Age
34 ±17 yrs

Experience
12 ±12 yrs



Key Findings

- **75% of injured respondents did not report their injuries to SLSNZ; of which 29% were unaware of procedures to report injuries ("occurred during training", "unaware", or "at fault")**
- **Landing in the IRB after being airborne and navigating a wave were the most reported causes of injuries**
- **Chronic injuries were reported by 15% of respondents as a long term health effect of surf lifesaving participation**

Diewald S.N., Hume P.A. et al. (2019). An overview of the issues for recreational and competitive surf lifesaving injuries associated with inflatable rescue boats: Technical report #6 to Surf Life Saving New Zealand (SLSNZ).

ABSTRACT – #3 SURVEY OF MEMBERS PREVIOUS INJURIES

Background: Due to their speed and manoeuvrability in often adverse sea conditions, inflatable rescue boats (IRB) were thought to cause injury to the crew members by Surf Life Saving New Zealand (SLSNZ).

Purpose: To use a questionnaire to quantify risk factors, aetiologies, and mechanisms of IRB-related injury associated with surf lifesaving activities in order to prescribe injury prevention strategies.

Methods: An on-line survey for SLSNZ members who completed a self-reported retrospective questionnaire. The "Sequence of Injury Prevention" approach proposed by van Mechelen, Hlobil [6] was applied to the questionnaire findings.

Results: Of 259 questionnaire respondents, 196 were included in the analysis (124 males: 39.1 ±17.1 years; 70 females: 24.9 ±11.9 years). Younger females experienced significantly more patrol injuries than older males. The most frequently injured body sites were the lower back (15.3% of respondents) and ankle (19.4% of respondents). Sprains and strains were the most reported injury types. Aetiology of injury was established as landing in the IRB for 14.8% of respondents. Chronic injury symptoms were reported by 15.6% of respondents.

Discussion: Utilisation of IRBs during surf lifesaving has a risk of injury to the lower extremities and back, particularly in younger females. Results are most likely an underestimate due to low respondent rates. Future research should consider lower extremity and back strength intervention strategies to help prevent IRB-related acute and chronic injuries.

Conclusion: Sprains and strains were the most common types of injuries for the lower extremity and back. Landing activities were most frequently reported as causing IRB-related injuries. Chronic injuries were reported which may impact long-term outcomes from surf lifesaving participation.

Recommendations:

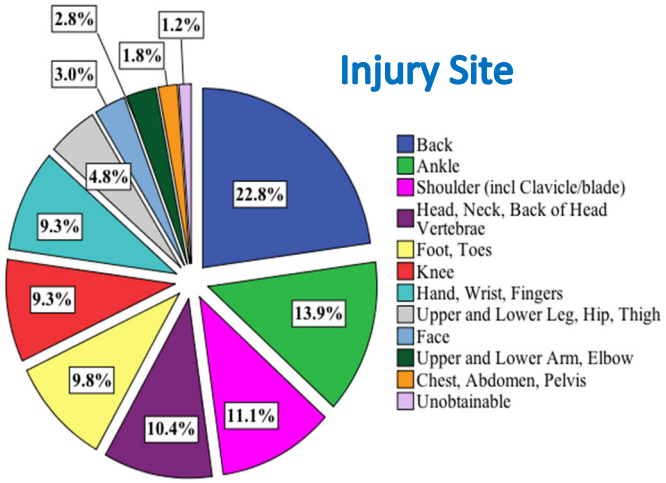
1. Current IRB crew member guidelines and strength requirements should be considered in order to assure crew members are able to stay inside the IRB and withstand the loads experienced during operation.

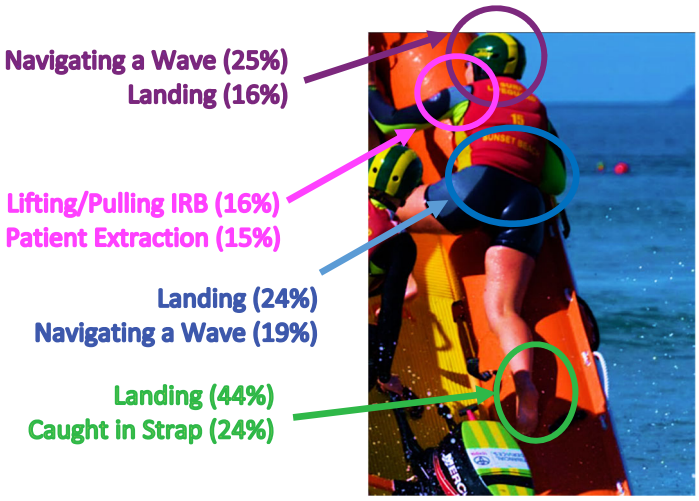
2. Preventative strategies such as age- and gender- specific strength training, warm-up protocols, and equipment changes should be implemented and investigated to determine effectiveness in reducing the occurrence of acute and chronic soft tissue injuries.

3. The physical fitness level of surf life savers in New Zealand should be assessed after developing a surf lifesaver task relevant fitness battery.

Surf Life Saving New Zealand ACC injuries - Fact Sheet

Injury Site

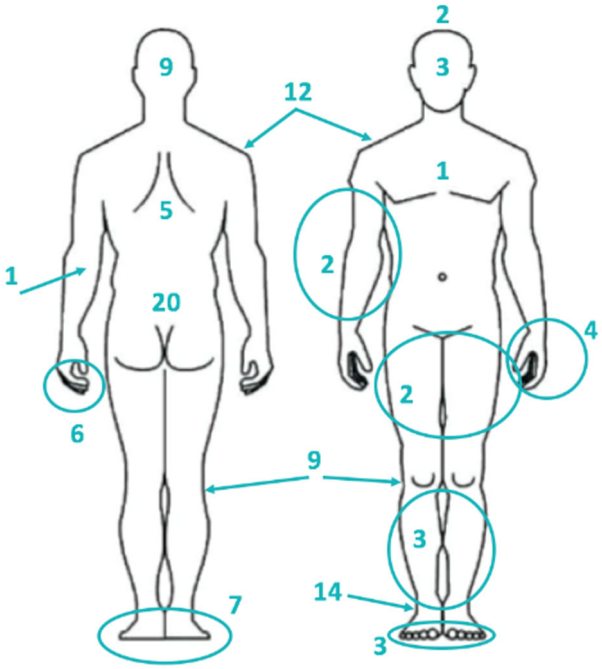




Lower Back

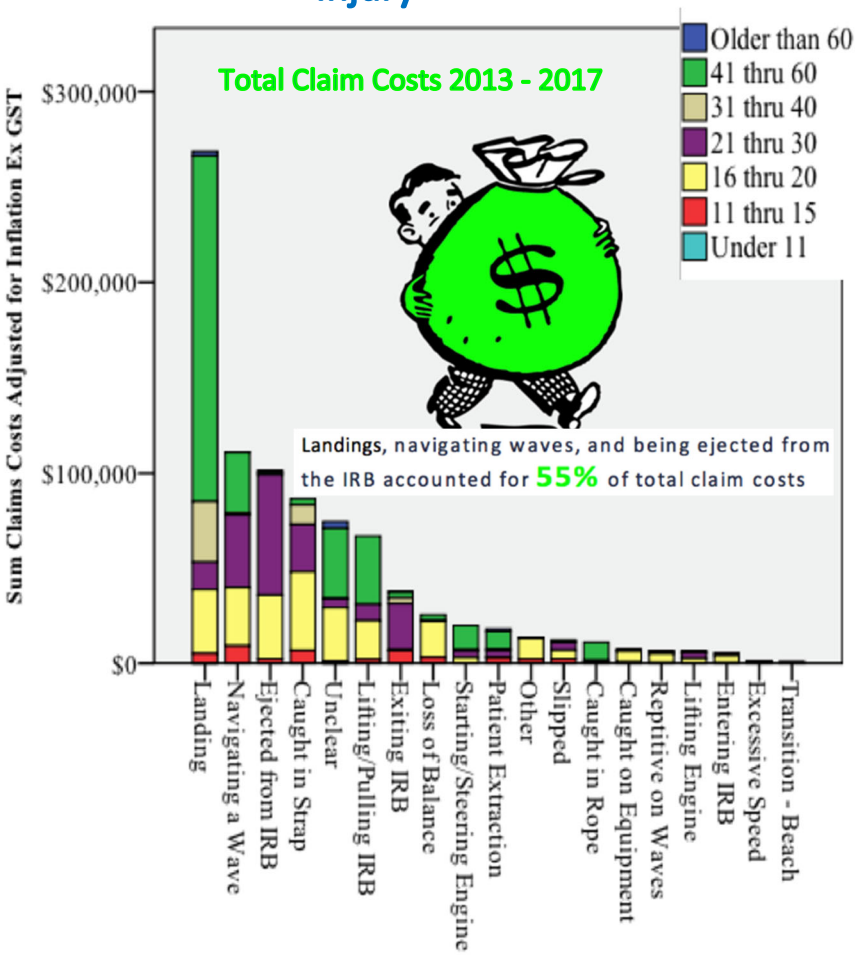
injuries made up 18.5% of all injury claims from 2013 to 2017. 1 out of 5 lower back injury claims were due to landing in the boat after being airborne in the IRB.

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). An overview of the issues for recreational and competitive surf lifesaving injuries associated with inflatable rescue boats: Technical report #6 to Surf Life Saving New Zealand (SLSNZ).

ABSTRACT – #4 ACC INJURY DATA

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) during 2013 to 2017 were retrospectively analysed to provide epidemiological data and related costs. The "sequence of injury prevention" approach proposed by van Mechelen, Hlobil [6] 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 life savers.

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.

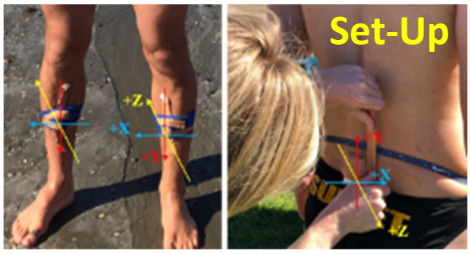
Conclusion: IRB-related ACC claims lodged for surf lifesaving per-day are high. Targeted injury prevention strategies must focus on lower back and ankle injuries.

Recommendations:

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

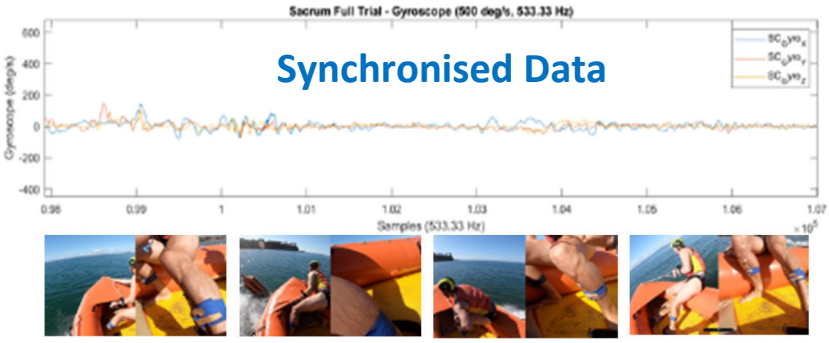
Surf Life Saving New Zealand boat and crew instrumentation biomechanics feasibility study - Fact Sheet

Equipment



Anthropometrics

Participant	IRB Crew Member	IRB Driver
Age	25 years	27 years
Height	195 cm	194 cm
Femur Length (right)	46.1 cm	47.0 cm
Body Weight	93.5 kg	94.5 kg



Key Findings

- A method to measure crew and boat accelerations and movement patterns was established
- Future studies should use inertial measurement sensors with an acceleration range of ±100 g sampling at 500 Hz
- Frequency analysis (e.g. power density spectrum) may help quantify loads associated with lower back pain
- Future research should standardise water-based maneuvers to compare across populations and conditions

Diewald S.N., Hume P.A. et al. (2019). An overview of the issues for recreational and competitive surf lifesaving injuries associated with inflatable rescue boats: Technical report #6 to Surf Life Saving New Zealand (SLSNZ).

ABSTRACT – #5 BOAT AND CREW INSTRUMENTATION

Background: Only two studies to date have investigated loads experienced on IRBs during operation.

Purpose: To pilot a data collection system for acceleration and video footage of the IRB and crew on water, to be used in subsequent studies of IRB-related activities.

Methods: A pair of experienced (national champion) surf lifesavers were utilised for this study (an IRB driver and a crew member). The crew member was instrumented with three inertial measurement sensors; left tibia, right tibia, and sacrum. An IRB provided by Sunset Beach Surf Life Saving Club was instrumented with 3 GoPro cameras in order to get a view of the entire IRB, crew member lower extremity, and surf conditions. The surf lifesavers performed a number of typical IRB maneuvers utilized during patrol and/or competition. The collected sensor and video data was imported and analysed for feasibility.

Results: The goal of the analysis of the feasibility study was to first identify if the sensors and video footage captured the necessary information. In order to identify tasks in the IMU data, time stamps were able to be matched with the video footage of interest. Camera footage was useful however locations of the cameras may need to be modified in future studies. Successful collection of accelerometer and gyroscope data demonstrated a need to investigate the vibration exposure of surf lifesavers while operations IRBs. Through a frequency analysis approach, identifying the power spectrum densities of the accelerometer and gyroscope signal may enable the comparisons of vibrations during different IRB crewing tasks under different techniques and body positions. This technique may help to identify age- and gender- specific load prescriptions in order to minimize the risk of developing low back pain.

Discussion: Only the ±16 g accelerometer was analysed as this was a feasibility pilot to assess if the method would work. Future studies should use inertial measurement sensors with an acceleration range of ±100g sampling at 500 Hz. The weather and water conditions were mild; thus future studies are recommended to determine feasibility in varying conditions. Due to the difficulty of assessing kinematics from the GoPro footage, future studies should investigate the different positioning of the crew members in a lab environment to assess potential injury mechanisms while varying IRB orientations.

Conclusions: Inertial sensors attached to surf lifesavers at the sacrum while operating IRBs may help quantify loads and frequencies associated with common injuries; such as, lower back pain and soft-tissue ankle injuries. Future research should standardise water-based maneuvers to compare across populations and conditions. Signal analysis techniques should be investigated under different water and weather conditions.

Recommendations:

Future research should be conducted under conditions with waves to assess the magnitude and frequency of biomechanical loading endured by the crew member.

Future research should attempt to standardize the manoeuvres in the water to compare across populations and conditions.

Future studies should investigate the different biomechanical positioning of the crew members in a lab environment with motion capture (e.g. VICON) to assess potential injury mechanisms.

Once the methods have been finetuned, future projects can evaluate boat design or crew movement changes.

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