

# Sports-related injuries in New Zealand: National Insurance (Accident Compensation Corporation) claims for five sporting codes from 2012 to 2016

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► Additional material is published online only. To view, please visit the journal online (<http://dx.doi.org/10.1136/bjsports-2017-098533>).

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Accepted 8 February 2018

## ABSTRACT

**Objectives** To provide epidemiological data and related costs for sport-related injuries of five sporting codes (cricket, netball, rugby league, rugby union and football) in New Zealand for moderate-to-serious and serious injury claims.

**Methods** A retrospective analytical review using detailed descriptive epidemiological data obtained from the Accident Compensation Corporation (ACC) for 2012–2016.

**Results** Over the 5 years of study data, rugby union recorded the most moderate-to-serious injury entitlement claims (25 226) and costs (New Zealand dollars (NZD\$)267 359 440 (£139 084 749)) resulting in the highest mean cost (NZD\$10 484 (£5454)) per moderate-to-serious injury entitlement claim. Rugby union recorded more serious injury entitlement claims (n=454) than cricket ( $t_{(4)}=-66.6$ ;  $P<0.0001$ ); netball ( $t_{(4)}=-45.1$ ;  $P<0.0001$ ); rugby league ( $t_{(4)}=-61.4$ ;  $P<0.0001$ ) and football ( $t_{(4)}=66.6$ ;  $P<0.0001$ ) for 2012–2016. There was a twofold increase in the number of female moderate-to-serious injury entitlement claims for football (RR 2.6 (95%CI 2.2 to 2.9);  $P<0.0001$ ) compared with cricket, and a threefold increase when compared with rugby union (risk ratio (RR) 3.1 (95%CI 2.9 to 3.3);  $P<0.0001$ ). Moderate-to-serious concussion claims increased between 2012 and 2016 for netball (RR 3.7 (95%CI 1.9 to 7.1);  $P<0.0001$ ), rugby union (RR 2.0 (95% CI 1.6 to 2.4);  $P<0.0001$ ) and football (RR 2.3 (95%CI 1.6 to 3.2);  $P<0.0001$ ). Nearly a quarter of moderate-to-serious injury entitlement claims (23%) and costs (24%) were to participants aged 35 years or older.

**Conclusions** Rugby union and rugby league have the highest total number and costs associated with injury. Accurate sport exposure data are needed to enable injury risk calculations.

## INTRODUCTION

People in New Zealand participate in sporting activities for reasons such as health, fitness, pleasure, relaxation or for the team environment.<sup>1</sup> Although sports participation can have healthy influences and assist with reducing risk factors such as cardiovascular disease,<sup>1</sup> injuries are a risk of sports participation.<sup>2</sup> Studies have reported the incidence of injuries during sports participation endeavouring to better understand what is occurring.<sup>3</sup> All sports injuries are a concern and organisations are constantly striving to improve the management and prevention of injuries to make their sports safer.<sup>4</sup> Injuries are one of the main reasons why individuals drop

out from sports participation.<sup>5</sup> One way to assist with identification of the extent of the sport injury problem, and the development of injury prevention programmes, is through injury epidemiology data analyses.<sup>1–6</sup> A source for injury data is the national insurance company in New Zealand, the Accident Compensation Corporation (ACC). Using data obtained from the ACC, studies have reported on rugby union,<sup>7–12</sup> rugby league,<sup>13–18</sup> cricket,<sup>12</sup> netball,<sup>6, 12</sup> sports-related concussion,<sup>19, 20</sup> dental injuries<sup>21, 22</sup> and the effects of injury prevention strategies.<sup>8, 9, 20, 23–25</sup> Most, but not all,<sup>14–16</sup> of these studies reported specific injuries<sup>6, 7, 10, 11, 13, 18, 20, 25</sup> or injury prevention strategies.<sup>9, 23, 24</sup> Some studies<sup>14–16</sup> reported directly on the number and associated costs of rugby league injuries over a 10-year period. Caldwell<sup>26</sup> highlighted that the cost of sports-related injuries in New Zealand has risen to NZD\$542 million (£281 970 524) and that the top sports codes by total injury costs in 2016 were rugby union (NZD\$78 242 505 (£40 704 945)), football (NZD\$38 295 109 (£19 922 679)), netball (NZD\$27 639 333 (£14 380 659)) and rugby league (NZD\$19 871 754 (£10 339 212)). The costs of sports injuries are increasing but there is a paucity of studies reporting on all injuries and the related costs. It has been previously been reported<sup>15</sup> that for 42 754 ACC injury entitlement claims over an 8-year period the total costs were NZD\$48 704 704 (£25 342 015). Moderate-to-serious claims represented 13.9% (5493) of the total number of claims but 87.9% (NZD\$42 822 048 (£22 281 153)) of the total costs. Although minor claims accounted for the majority (86.1%) of claims they only accounted for 12.1% of the total costs. Therefore, the aim of this study was to provide a retrospective analytical review on the moderate-to-serious and serious injury claims and related costs for five sporting codes (cricket, netball, rugby league, rugby union and football) in New Zealand.

## METHODS

### The quality of the New Zealand ACC injury reporting system and data

As there are no reliable data capturing systems for injuries within national sports organisations in New Zealand, the ACC database was used to provide detailed descriptive epidemiological data including the costs associated with treatment for injuries occurring in sporting activities. The ACC records, and reports, on different types of acute personal injury claims.<sup>20</sup> The database records the number



**To cite:** King D, Hume PA, Hardaker N, et al. *Br J Sports Med* Epub ahead of print: [please include Day Month Year]. doi:10.1136/bjsports-2017-098533

of injury claims but is unable to report length of hospital stay, missed match or loss of training time and participation level. The terms minor, moderate-to-serious and serious entitlement claims are defined under the Injury Prevention, Rehabilitation and Compensation Act, 2001 with the ACC responsible for meeting the costs of these injuries.<sup>20</sup> People qualify for cover when they present with a personal acute injury as a result of an accident to any of the 30 000 ACC registered medical practitioners throughout New Zealand.<sup>20</sup> When making a claim, injury information is collected using a standard ACC 45 injury reporting form to ensure levels of consistency for data recording and analyses.<sup>15</sup> The injured person (unless impaired) completes information relating to the activity surrounding the injury (eg, location, activity prior, cause, narrative), and personal details (eg, age, gender, ethnicity, contact details). The registered health professional completes the form by providing information regarding initial diagnosis and other relevant medical information (eg, surgical procedure). The claim is filed with the ACC and details are entered into a central database. The ACC covers compensation for the injury (sporting or other) including medical treatment, income replacement, social and vocational rehabilitation and ancillary services (transportation and accommodation) as part of the rehabilitation.

Epidemiological studies are dependent on data quality for any analysis to be undertaken.<sup>23</sup> There is no disincentive by ACC for making claims, nor are people risk-rated or penalised for the amount of claims they make.<sup>23</sup> Coverage is guaranteed by ACC, but this is offset by the restriction to sue for personal injury except in rare circumstances for exemplary damages.<sup>23</sup> ACC injury entitlement claims are categorised as minor (medical treatment only), moderate-to-serious<sup>23</sup> or serious.<sup>11 27</sup> Minor claims are lodged following an accident and generate a payment for the period reported to the registered medical practitioner (eg, physiotherapist, general practitioner) for the medical treatment provided.<sup>20</sup> Typically minor claims do not require loss of time from employment, where the claimant does not require additional medical support and involves a few treatments with the ACC meeting most of the costs.<sup>20</sup> Moderate-to-serious injury

entitlement claims occur following an accident, generate a payment for the period reported and require additional financial support for treatment, loss of earnings and related medical costs.<sup>20 23</sup> Serious injury entitlement claims require a prolonged period of financial support, loss of earnings and related medical support and are monitored by the Serious Injury Claim Unit, typically over a long period of time.<sup>11 27</sup> Moderate-to-serious and serious injury entitlement claims account for approximately 8% of total claims recorded, but can account for 80% of total costs.<sup>9 20 23</sup>

This study focused on moderate-to-serious and serious injury entitlement claims that occurred from 1 January 2012 to 31 December 2016 resulting from participating in five sporting activities. The definition used for this study was 'any injury that had been assessed and reported by a registered health practitioner as a result of sports participation'. The injury also had to have been accepted as an ACC claim during the study period to be recorded in the study dataset. All costs were inflation adjusted using the Reserve Bank inflation adjustor (<https://www.rbnz.govt.nz/monetary-policy/inflation-calculator>) to reflect all costs at 2016 rates with a mean inflation of 2.8%±1.3% per year.

### Ethical consent

Informed consent from the injured participants was not obtained as de-identified data were collected from the ACC database without individual participant identification or follow-up.

### Statistical analysis

All data collected were entered into a Microsoft Excel spreadsheet and analysed with SPSS (IBM, Released 2017, IBM SPSS Statistics for Windows, V.24.0, Armonk, New York, USA). Data are reported as means and ±SD with 95% CI where appropriate.<sup>28</sup> Comparisons of the costs over the reporting years were calculated using an independent t-test. A one-sample  $\chi^2$  test was used for comparison between reporting years for the number of claims recorded. Injury incidence was not calculated for the study as the sporting codes participation rates were not available as part of the data analysis.

**Table 1** Sports code summary of Accident Compensation Corporation moderate-to-serious and serious injury entitlement claims and costs, for total number of claims, total costs, mean costs per claim and per reporting year with 95% CIs, for five sports from 2012 to 2016 in New Zealand

Sports code	Claims			Costs NZD\$			
	Total	%*	Mean±SD per year	Total cost	%†	Mean cost per year (95% CI)	Mean cost per claim (95% CI)
<b>Moderate-to-serious injury claims</b>							
Rugby union	25 226 <sup>acdef</sup>	3	5045±360	\$267 359 440 <sup>acdef</sup>	34.4	\$52 990 715 (\$46 211 711 to \$59 769 719)	\$10 484 (\$10 018 to \$10 951)
Football	14 240 <sup>abdef</sup>	1.7	2848±357	\$99 237 392 <sup>abdef</sup>	12.8	\$19 672 411 (\$15 522 575 to \$23 822 306)	\$6438 (\$6438 to \$7315)
Netball	11 748 <sup>abcef</sup>	1.4	2350±167	\$74 706 089 <sup>abcef</sup>	9.6	\$14 808 594 (\$11 933 591 to \$17 683 596)	\$6272 (\$5593 to \$6951)
Rugby league	6517 <sup>abcdf</sup>	0.8	1303±105	\$63 797 127 <sup>abcdf</sup>	8.2	\$12 674 465 (\$10 559 203 to \$14 735 727)	\$9681 (\$8 871 to \$10 490)
Cricket	3072 <sup>abcde</sup>	0.4	614±88	\$24 258 835 <sup>abcde</sup>	3.1	\$4 809 257 (\$3 614 679 to \$6 003 835)	\$7802 (\$6623 to \$8981)
Total	60 803 <sup>a</sup>	7.1	2432±1570	\$529 358 883 <sup>a</sup>	68	\$104 928 473 (\$11 027 826 to \$220 884 773)	\$8248 (\$6013 to \$10 483)
<b>Serious injury claims</b>							
Rugby union	454 <sup>cdef</sup>	0.1	91±3	\$72 795 782 <sup>acde</sup>	9.4	\$14 888 363 (\$13 612 130 to \$16 164 596)	\$161 109 (\$139 958 to \$186 259)
Football	15 <sup>be</sup>	0	3±0	\$608 175 <sup>abe</sup>	0.1	\$143 623 (\$113 398 to \$173 849)	\$48 177 (\$2971 to \$99 281)
Netball	9 <sup>be</sup>	0	3±0	\$320 399 <sup>be</sup>	0	\$106 766 (\$25 548 to \$539 080)	\$2111 (\$203 to \$24 226)
Rugby league	104 <sup>bcdf</sup>	0	21±1	\$12 691 174 <sup>abcdf</sup>	1.6	\$2 565 153 (\$1 731 574 to \$3 398 732)	\$118 957 (\$27 479 to \$210 435)
Cricket	15 <sup>be</sup>	0	3±0	\$447 014 <sup>e</sup>	0.1	\$53 566 (\$25 827 to \$81 305)	\$9371 (\$166 to \$30 908)
Total	597	0.1	26±36	\$86 862 544 <sup>a</sup>	11.2	\$17 362 840 (\$16 161 224 to \$18 564 456)	\$142 584 (\$132 467 to \$152 700)

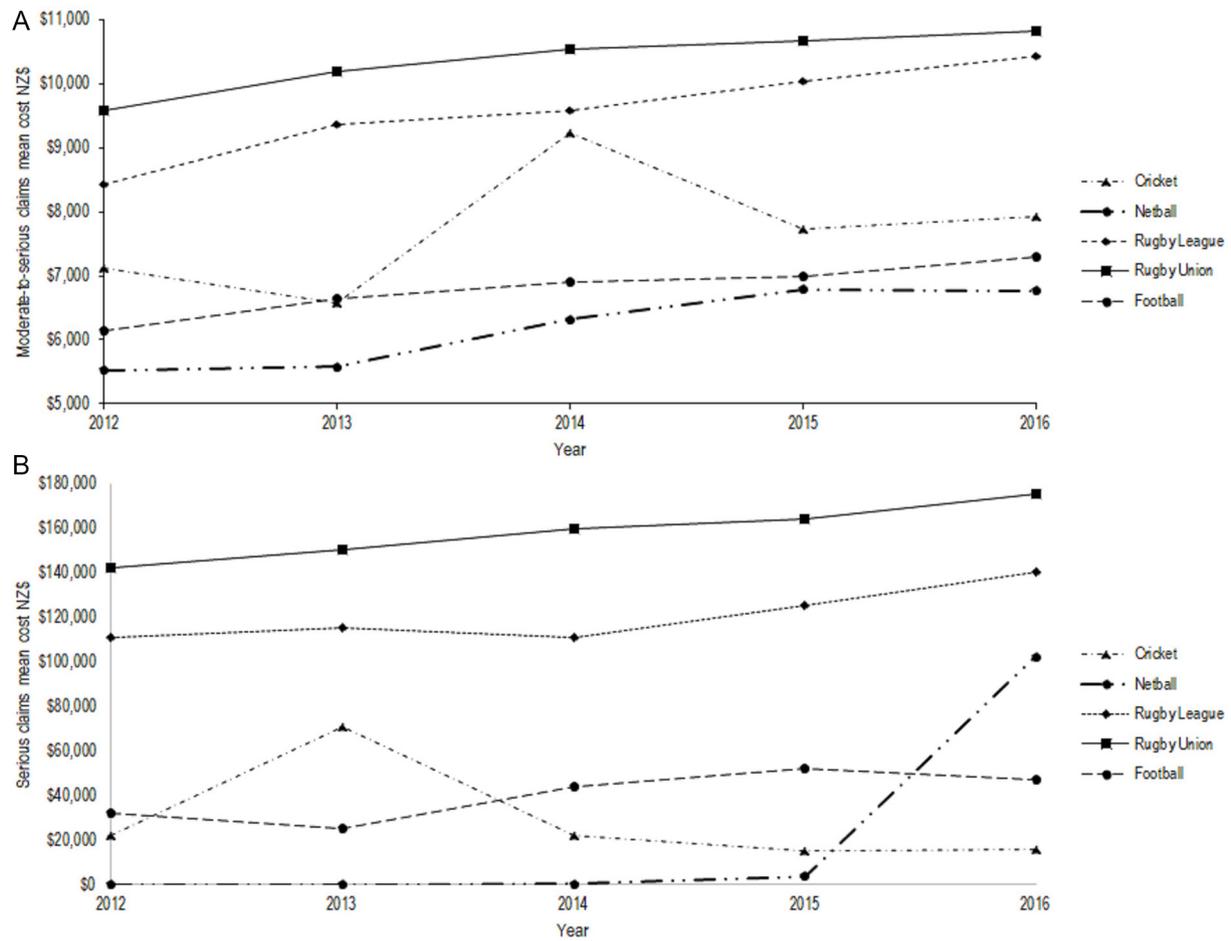
All costs are inflation adjusted to 2016 values; significant difference ( $P < 0.05$ ).

\*Percentage of total claims.

†Total costs.

(a), Across reporting years (2012–2016); (b), rugby union; (c), football; (d), netball; (e), rugby league; (f), cricket.

NZD\$, New Zealand dollars.



**Figure 1** Mean cost per year for (A) moderate-to-serious and (B) serious injury entitlement claims, for rugby union, football, netball, rugby league and cricket. NZD\$, New Zealand dollars.

All costs are reported in New Zealand dollars (NZD\$) and Great Britain Pounds (£) unless otherwise indicated.

## RESULTS

Throughout 2012–2016 there were 853 824 total claims costing ACC NZD\$777 939 840 (equivalent to £404 805 406) with an average cost per year of NZD\$155 587 968 (95% CI NZD\$12 462 949 to NZD\$311 238 885) (£80 961 081 (95% CI £6 484 816 to £161 946 176)). The moderate-to-serious and serious injury entitlement claims represented 7.2% (61 412) of total claims for the five sports codes, but 78.6% (NZD\$611 456 567 (£318 207 349)) of the total injury entitlement costs with a mean cost per year of NZD\$122 291 313 (95% CI NZD\$31 025 952 to NZD\$275 608 579) (£63 659 340 (95% CI £16 150 711 to £143 521 314)). Minor injuries accounted for 7.2% of the total claims and 21.4% of the total costs (NZD\$166 483 148 (£86 603 122)) with a mean cost per year of NZD\$33 296 629 (95% CI NZD\$30 632 006 to NZD\$35 961 253) (£17 318 733 (95% CI £15 932 899 to £18 703 803)). As a result, minor injuries had a mean cost of NZD\$210 (95% CI NZD\$205 to NZD\$215) (£109 (95% CI £107 to £112)) per claim.

### Total, moderate-to-serious and serious ACC injury entitlement claims

Over the 2012–2016 period, there were 60 803 moderate-to-serious and 597 serious injury entitlement claims recorded for

five sports (table 1). Moderate-to-serious injury entitlement claims recorded the highest total costs (NZD\$529 358 883 (£275 682 788)) resulting in an average cost of NZD\$8248 (95% CI NZD\$6013 to NZD\$10 483) (£4296 (95% CI £3131 to £5460)) per injury entitlement claim. There were  $2432 \pm 1570$  moderate-to-serious injury entitlement claims per year costing an average of NZD\$104 928 473 (95% CI NZD\$11 027 826 to NZD\$220 884 773) (£54 625 125 (95% CI £5 741 019 to £114 991 269)) per year. Serious injury entitlement claims were less (NZD\$86 862 544 (£45 227 843)) but had the highest average cost (NZD\$142 584 (95% CI NZD\$132 467 to NZD\$152 700) (£74 241 (95% CI £68 973 to £79 508))) per claim. Rugby union recorded the most moderate-to-serious injury entitlement claims (25 226) and costs (NZD\$267 359 440 (£139 220 573)) and, as a result, had the highest mean cost (NZD\$10 484 (95% CI NZD\$10 018 to NZD\$10 951) (£5459 (95% CI £5217 to £5702))) per moderate-to-serious injury entitlement claim. Rugby union also recorded more serious injury entitlement claims ( $n=454$ ) than cricket ( $t_{(4)}=-66.6$ ;  $P<0.0001$ ); netball ( $t_{(4)}=-45.1$ ;  $P<0.0001$ ); rugby league ( $t_{(4)}=-61.4$ ;  $P<0.0001$ ) and football ( $t_{(4)}=66.6$ ;  $P<0.0001$ ) during the study.

### Reporting years moderate-to-serious and serious injury entitlement claims

Figure 1 illustrates the mean cost per year for moderate-to-serious claims and serious claims for the five sports. The two

**Table 2** Sports code summary of Accident Compensation Corporation moderate-to-serious and serious injury entitlement claims and costs of female and males by total number of claims, total costs, mean costs per claim and per reporting year with 95% CIs, for five sports in New Zealand from 2012 to 2016

	Moderate-to-serious claims			Serious claims		
	Claims (n=)	Costs in NZD\$		Claims (n=)	Costs in NZD\$	
		Total	Mean (95% CI) per claim		Total	Mean (95% CI) per claim
<b>Rugby union</b>						
Female	1396 <sup>adf</sup>	\$11 076 670 <sup>acdef</sup>	\$6950 (\$6750 to \$7158)	15 <sup>cf</sup>	\$6 462 285 <sup>a</sup>	\$43 373 (\$39 548 to \$47 197)
Male	23 830 <sup>adf</sup>	\$256 282 770 <sup>acdef</sup>	\$10 694 (\$10 151 to \$11 236)	439	\$72 149 497 <sup>acef</sup>	\$1 605 92 (\$147 199 to \$173 986)
Total	25 226 <sup>acdef</sup>	\$267 359 440 <sup>acdef</sup>	\$10 582 (\$10 142 to \$11 022)	454 <sup>cdf</sup>	\$72 795 782 <sup>acde</sup>	\$1 673 53 (\$148 539 to \$186 168)
<b>Football</b>						
Female	2468 <sup>abdef</sup>	\$14 785 722 <sup>abdef</sup>	\$5813 (\$5427 to \$6199)	0	to	to
Male	11 772 <sup>abdef</sup>	\$84 451 670 <sup>abdef</sup>	\$7100 (\$6631 to \$7568)	15	\$6 081 75 <sup>abe</sup>	\$47 875 (\$37 799 to \$57 950)
Total	14 240 <sup>abdef</sup>	\$99 237 392 <sup>abdef</sup>	\$6940 (\$6526 to \$7032)	15 <sup>be</sup>	\$6 081 75 <sup>abe</sup>	\$47 875 (\$37 799 to \$57 950)
<b>Netball</b>						
Female	10 061 <sup>abcef</sup>	\$62 709 324 <sup>abcef</sup>	\$6197 (\$5490 to \$6902)	9 <sup>bcef</sup>	\$3 203 99 <sup>be</sup>	\$35 589 (\$10 851 to \$179 694)
Male	1687 <sup>bcef</sup>	\$11 996 765 <sup>abcef</sup>	\$6720 (\$5938 to \$7503)	0	to	to
Total	11 748 <sup>abcef</sup>	\$74 706 089 <sup>abcef</sup>	\$6330 (\$5664 to \$6995)	9 <sup>be</sup>	\$3 203 99 <sup>be</sup>	\$35 589 (\$10 851 to \$179 694)
<b>Rugby league</b>						
Female	365 <sup>acdf</sup>	\$2 934 902 <sup>abcd</sup>	\$7101 (\$5481 to \$8720)	6 <sup>d</sup>	\$1 944 34 <sup>a</sup>	\$32 405 (\$24 775 to \$40 036)
Male	6152 <sup>acf</sup>	\$60 862 225 <sup>abcd</sup>	\$9834 (\$8975 to \$10 691)	98 <sup>d</sup>	\$12 496 740 <sup>abcf</sup>	\$1 219 54 (\$98 621 to \$145 288)
Total	6517 <sup>abcd</sup>	\$63 797 127 <sup>abcd</sup>	\$9769 (\$8991 to \$10 547)	104 <sup>bcd</sup>	\$12 691 174 <sup>abcd</sup>	\$1 261 55 (\$90 393 to \$161 917)
<b>Cricket</b>						
Female	208 <sup>bcd</sup>	\$1 645 796 <sup>abcd</sup>	\$7470 (\$4801 to \$10 138)	3 <sup>bd</sup>	\$1 643 82	\$27 231 (\$11 618 to \$56 080)
Male	2864 <sup>abd</sup>	\$22 613 039 <sup>abcde</sup>	\$7835 (\$6414 to \$9256)	12	\$2 826 32 <sup>abe</sup>	\$19 532 (\$14 340 to \$24 724)
Total	3072 <sup>abce</sup>	\$24 258 835 <sup>abcde</sup>	\$7875 (\$6685 to \$9066)	15 <sup>be</sup>	\$4 470 14 <sup>e</sup>	\$17 856 (\$8609 to \$21 102)

All costs are inflation adjusted to 2016 values; significant difference ( $P < 0.05$ ).

(a), Across reporting years (2012–2016); (b), rugby union; (c), football; (d), netball; (e), rugby league; (f), cricket. NZD\$, New Zealand dollars.

rugby codes had the highest mean costs per claim (a surrogate measure of severity of the injury) for the moderate-to-serious claims and the serious claims. All sports showed an increase in the mean cost per year over the 5 years for the moderate-to-serious claims. The same trend of increasing mean cost per year was seen for the serious claims over the years for the sports. There was a fourfold increase in mean cost in 2013 for cricket and a large increase for netball from prior years for the 2015 mean claims costs for serious claims. Details of the yearly numbers and costs for the claims per sport are available in online supplementary table S1.

### Gender moderate-to-serious and serious injury entitlement claims

There were differences in the number of moderate-to-serious injury entitlement claims for females between 2012 and 2016 for netball (RR 1.2 (95% CI 1.1 to 1.3);  $P < 0.0001$ ), rugby league (RR 2.0 (95% CI 1.5 to 2.7);  $P < 0.0001$ ), rugby union (RR 1.9 (95% CI 1.6 to 2.2);  $P < 0.0001$ ) and football (RR 1.4 (95% CI 1.3 to 1.6);  $P < 0.0001$ ) (table 2). The mean costs per moderate-to-serious injury entitlement claim varied from NZD\$6330 (95% CI NZD\$5664 to NZD\$6995) (£3297 (95% CI £2950 to £3643)) for netball to NZD\$10 582 (95% CI NZD\$10 142 to NZD\$11 022) (£5647 (95% CI £5278 to £5736)) for rugby union. The costs of moderate-to-serious injury entitlement claims for females (NZD\$14 339 203 to NZD\$21 797 582 (£77 463 351 to £11 345 666);  $t_{(4)} = 12.6$ ;  $P = 0.0002$ ) and males (NZD\$74 964 427 to NZD\$98 571 975 (£39 041 592 to £51 336 440);  $t_{(4)} = 18.8$ ;  $P = 0.0001$ ) increased during the study. Females recorded the highest mean cost per serious injury entitlement claim (NZD\$43 373 (95% CI NZD\$39 548

to NZD\$47 197) (£22 587 (95% CI £20 595 to £24 579))) in rugby union. There was a twofold increase in the number of female moderate-to-serious injury entitlement claims for football (RR 2.6 (95% CI 2.2 to 2.9);  $P < 0.0001$ ) when compared with cricket, and a threefold increase when compared with rugby union (RR 3.1 (95% CI 2.9 to 3.3);  $P < 0.0001$ ).

### Injury site moderate-to-serious and serious injury entitlement claims

The number of moderate-to-serious injury entitlement claims increased for lower limb injuries over 2012–2016 for cricket ( $\chi^2_{(4)} = 12.8$ ;  $P = 0.0123$ ), netball ( $\chi^2_{(4)} = 32.5$ ;  $P < 0.0001$ ), rugby league ( $\chi^2_{(4)} = 10.6$ ;  $P = 0.0310$ ), rugby union ( $\chi^2_{(4)} = 18.8$ ;  $P = 0.0009$ ) and football ( $\chi^2_{(4)} = 101.3$ ;  $P < 0.0001$ ) (table 3). Rugby union ( $n = 2779$ ) recorded more head/neck injuries than cricket ( $n = 212$ ;  $t_{(4)} = -2.6$ ;  $P = 0.0456$ ) during the study. The costs of moderate-to-serious injury entitlement claims increased during the study for injuries to the head and neck for rugby union ( $t_{(4)} = 30.0$ ;  $P < 0.0001$ ), netball ( $t_{(4)} = 8.7$ ;  $P = 0.0010$ ) and rugby league ( $t_{(4)} = 36.1$ ;  $P < 0.0001$ ). Rugby union recorded the highest average cost per moderate-to-serious (NZD\$25 237 (95% CI NZD\$22 733 to NZD\$27 741) (£13 138 (95% CI £11 834 to £14 437))) and serious (NZD\$1 795 13 (95% CI NZD\$1 664 410 to NZD\$1 926 616) (£93 424 (95% CI £86 605 to £100 234))) injury entitlement claim for the head/neck during 2012–2016. The knee recorded the most moderate-to-serious injury entitlement claims ( $n = 19 026$ ) and costs (NZD\$172 178 936 (£89 598 967)) but the neck, back of head vertebrae recorded the highest mean cost per moderate-to-serious injury entitlement claim (NZD\$77 428 (95% CI NZD\$26 732 to NZD\$128 123) (£40 293 (95% CI £13 911 to £66 675))) (see online supplementary table S2).

**Table 3** Sports code summary of Accident Compensation Corporation moderate-to-serious and serious injury entitlement claims and costs of anatomical group by total number of claims, total costs, mean costs per claim and per reporting year with 95% CIs, for five sports in New Zealand from 2012 to 2016

	Moderate--serious claims			Serious claims		
	Claims (n=)	Costs in NZD\$		Claims (n=)	Costs in NZD\$	
		Total	Mean (95% CI) per claim		Total	Mean (95% CI) per claim
<b>Rugby union</b>						
Head/neck	2779 <sup>a</sup>	\$75 027 020 <sup>acdef</sup>	\$25 237 (\$22 733 to \$27 741)	348	\$62 980 144 <sup>acef</sup>	\$1 795 13 (\$1 664 10 to \$1 926 16)
Upper limb	8996 <sup>a</sup>	\$78 414 146 <sup>acdef</sup>	\$8113 (\$7556 to \$8670)	15	\$1 098 531 <sup>a</sup>	\$72 969 (\$58 617 to \$87 320)
Lower limb	11 219 <sup>a</sup>	\$95 899 475 <sup>acdef</sup>	\$7988 (\$7247 to \$8730)	15	\$6 562 86 <sup>af</sup>	\$43 089 (\$40 488 to \$45 691)
Chest/back/other	602	\$18 018 799 <sup>acdef</sup>	\$11 805 (\$11 245 to \$12 365)	50	\$8 060 821 <sup>ade</sup>	\$1 027 08 (\$70 891 to \$134 525)
Total	25 226 <sup>acdef</sup>	\$267 359 440 <sup>acdef</sup>	\$10 582 (\$10 142 to \$11 022)	454 <sup>cdf</sup>	\$72 795 782 <sup>acde</sup>	\$1 673 53 (\$148 539 to \$186 168)
<b>Football</b>						
Head/neck	773 <sup>a</sup>	\$16 474 290 <sup>abdef</sup>	\$28 947 (\$7729 to \$95 623)	9	\$1 780 12 <sup>be</sup>	\$19 552 (\$1 660 to \$40 764)
Upper limb	2146 <sup>a</sup>	\$13 961 754 <sup>abdef</sup>	\$7373 (\$6304 to \$8442)	0	\$0	–
Lower limb	10 295 <sup>a</sup>	\$66 472 381 <sup>abdef</sup>	\$8799 (\$2754 to \$14 843)	0	\$0	–
Chest/back/other	232	\$2 328 967 <sup>abdef</sup>	\$6999 (\$4384 to \$9614)	15	\$4 301 63 <sup>abe</sup>	\$28 322 (\$5 684 to \$50 960)
Total	14 240 <sup>abdef</sup>	\$99 237 392 <sup>abdef</sup>	\$6940 (\$6526 to \$7032)	15 <sup>ef</sup>	\$6 081 75 <sup>abe</sup>	\$47 875 (\$37 799 to \$57 950)
<b>Netball</b>						
Head/neck	282 <sup>a</sup>	\$2 263 039 <sup>abce</sup>	\$8042 (\$6991 to \$9093)	0	\$0	–
Upper limb	1217	\$7 090 408 <sup>abcef</sup>	\$5551 (\$4003 to \$7098)	0	\$0	–
Lower limb	9631 <sup>a</sup>	\$62 985 236 <sup>abcef</sup>	\$6218 (\$5457 to \$9798)	0	\$0	–
Chest/back/other	67	\$2 367 406 <sup>abce</sup>	\$7327 (\$4472 to \$10 183)	9	\$3 203 99 <sup>be</sup>	\$35 589 (\$10 851 to \$179 694)
Total	11 748 <sup>abcef</sup>	\$74 706 089 <sup>abce</sup>	\$6330 (\$5664 to \$6995)	9 <sup>be</sup>	\$3 203 99 <sup>be</sup>	\$35 589 (\$10 851 to \$179 694)
<b>Rugby league</b>						
Head/neck	577	\$10 097 516 <sup>abcdf</sup>	\$14 639 (\$13 103 to \$16 175)	66	\$8 650 534 <sup>abcdf</sup>	\$90 965 (\$77 405 to \$104 525)
Upper limb	2489 <sup>a</sup>	\$21 853 578 <sup>abcdf</sup>	\$8074 (\$7222 to \$8926)	0	\$0	–
Lower limb	2902 <sup>a</sup>	\$27 137 436 <sup>abcdf</sup>	\$8188 (\$7372 to \$9003)	0	\$0	–
Chest/back/other	209	\$4 708 597 <sup>abcdf</sup>	\$15 676 (\$12 492 to \$18 859)	30	\$4 040 640 <sup>abd</sup>	\$95 494 (\$71 646 to \$119 342)
Total	6517 <sup>abcdf</sup>	\$63 797 127 <sup>abcdf</sup>	\$9769 (\$8991 to \$10 547)	104 <sup>abcdf</sup>	\$12 691 174 <sup>abcdf</sup>	\$1 261 55 (\$90 393 to \$161 917)
<b>Cricket</b>						
Head/neck	212	\$3 450 788 <sup>abce</sup>	\$13 510 (\$2251 to \$29 273)	15	\$2 826 00 <sup>abd</sup>	\$11 934 (\$4719 to \$38 588)
Upper limb	1086 <sup>a</sup>	\$7 839 018 <sup>abcde</sup>	\$6679 (\$6142 to \$7 215)	0	\$0	–
Lower limb	1394 <sup>a</sup>	\$10 062 669 <sup>abcde</sup>	\$6810 (\$6631 to \$6990)	12	\$1 644 14	\$13 707 (\$8104 to \$55 518)
Chest/back/other	72	\$2 906 360 <sup>abce</sup>	\$9633 (\$6779 to \$12 487)	0	\$0	–
Total	3072 <sup>abce</sup>	\$24 258 835 <sup>abcde</sup>	\$7875 (\$6685 to \$9066)	15 <sup>be</sup>	\$4 470 14 <sup>abd</sup>	\$17 856 (\$8609 to \$21 102)

All costs are inflation adjusted to 2016 values; significant difference ( $P < 0.05$ ).

(a), Across reporting years (2012–2016); (b), rugby union; (c), football; (d), netball; (e), rugby league; (f), cricket. NZD\$, New Zealand dollars.

### Injury type moderate-to-serious and serious injury entitlement claims

The number of moderate-to-serious injury entitlement claims for fracture/dislocations increased over 2012–2016 for cricket ( $\chi^2_{(4)} = 25.5$ ;  $P < 0.0001$ ), rugby union ( $\chi^2_{(4)} = 17.8$ ;  $P = 0.0014$ ) and football ( $\chi^2_{(4)} = 37.5$ ;  $P < 0.0001$ ) (table 4). Moderate-to-serious concussion claims increased between 2012 and 2016 for netball (RR 3.7 (95% CI 1.9 to 7.1);  $P < 0.0001$ ), rugby union (RR 2.0 (95% CI 1.6 to 2.4);  $P < 0.0001$ ) and football (RR 2.3 (95% CI 1.6 to 3.2);  $P < 0.0001$ ). Rugby union recorded the highest total costs for moderate-to-serious injury entitlement claims for soft tissue injuries (NZD\$140 783 951 (£73 273 813)) and football recorded the highest average cost per moderate-to-serious injury entitlement claim for gradual onset (NZD\$14 964 (95% CI NZD\$4014 to NZD\$25 911 (£7790 (95% CI £2090 to £13 490))). Although rugby union recorded a higher total cost for moderate-to-serious injury entitlement concussion claims (NZD\$6 796 172 (£3 538 987)) than rugby league (NZD\$3 606 561 (£1 878 053);  $t_{(4)} = -6.7$ ;  $P = 0.0026$ ), rugby league recorded a higher average cost per moderate-to-serious injury entitlement claim (NZD\$15 925 (95% CI NZD\$14 121 to NZD\$17 730) vs NZD\$6611 (95% CI NZD\$5769 to

NZD\$7454) (£8294 (95% CI £7355 to £9235) vs £3444 (95% CI £3005 to £3883));  $t_{(4)} = 12.1$ ;  $P = 0.0003$ ). Serious injury entitlement claims costs differed by sport for fracture dislocations (rugby union:  $t_{(4)} = 21.7$ ;  $P < 0.0001$ ; rugby league:  $t_{(4)} = 11.5$ ;  $P = 0.0003$ ), concussions (rugby union:  $t_{(4)} = 22.4$ ;  $P < 0.0001$ ; rugby league:  $t_{(4)} = 13.2$ ;  $P = 0.0002$ ) and soft tissue injuries (rugby union:  $t_{(4)} = 46.8$ ;  $P < 0.0001$ ; rugby league:  $t_{(4)} = 11.2$ ;  $P = 0.0004$ ).

### Age group moderate-to-serious and serious injury entitlement claims

The 20–24 years age group recorded 23.7% ( $n = 14 401$ ) of the total moderate-to-serious injury entitlement claims and 22.4% (NZD\$118 335 586 (£61 641 914)) of the total moderate-to-serious injury entitlement costs (see online supplementary table S3). Nearly a quarter of the moderate-to-serious entitlements claims (22.9%) and costs (23.7%) were to participants aged 35 years or older. Participants aged 50–54 years recorded 2.1% of the total moderate-to-serious injury entitlement claims, 2.5% of the total moderate-to-serious injury entitlement costs but had the highest mean cost (NZD\$10 038 (95% CI NZD\$9533 to NZD\$10 543)

**Table 4** Sports code summary of Accident Compensation Corporation moderate-to-serious and serious injury entitlement claims and costs, of injury type by total number of claims, total costs, mean costs per claim and per reporting year with 95% CIs, for five sports in New Zealand from 2012 to 2016

	Rugby union			Football			Netball			Rugby league			Cricket		
	Total	Costs NZD\$	Mean (95% CI) per claim	Total	Costs NZD\$	Mean (95% CI) per claim	Total	Costs NZD\$	Mean (95% CI) per claim	Total	Costs NZD\$	Mean (95% CI) per claim	Total	Costs NZD\$	Mean (95% CI) per claim
Moderate-to-serious claims	14 300 <sup>a</sup>	\$1 407 783 951 <sup>acdef</sup>	\$8529 (\$8046 to \$9012)	9818 <sup>a</sup>	\$74 001 659 <sup>ghdef</sup>	\$7162 (\$6886 to \$7639)	9593 <sup>a</sup>	\$61 767 002 <sup>bcdef</sup>	\$6272 (\$5567 to \$6976)	3453 <sup>a</sup>	\$34 379 950 <sup>bcdef</sup>	\$8731 (\$8066 to \$9396)	1980 <sup>a</sup>	\$18 204 326 <sup>bcdef</sup>	\$8459 (\$6638 to \$10 280)
Soft tissue injury	9419 <sup>a</sup>	\$1 166 655 870 <sup>acdef</sup>	\$12634 (\$11 789 to \$13 481)	3880 <sup>a</sup>	\$23 054 232 <sup>ghdef</sup>	\$5956 (\$5465 to \$6447)	1965	\$11 929 929 <sup>bcdef</sup>	\$5460 (\$4406 to \$6515)	2636	\$24 960 469 <sup>bcdef</sup>	\$8953 (\$8033 to \$9874)	948 <sup>a</sup>	\$4 856 390 <sup>bcdef</sup>	\$5333 (\$4883 to \$5783)
Fracture/dislocation	991 <sup>a</sup>	\$6 796 172 <sup>acdef</sup>	\$6811 (\$5769 to \$7454)	285 <sup>a</sup>	\$8 945 575 <sup>bcde</sup>	\$3239 (\$2145 to \$4334)	105 <sup>a</sup>	\$825 419 <sup>bcde</sup>	\$9158 (\$5066 to 251)	284	\$3 606 561 <sup>bcdef</sup>	\$15925 (\$14 121 to \$17 730)	44	\$748 968 <sup>bcde</sup>	\$15 567 (\$5818 to \$25 316)
Concussion/brain injury	322	\$1 414 811 <sup>bcdef</sup>	\$4656 (\$3763 to \$5349)	165	\$6 872 552 <sup>bcdef</sup>	\$4978 (\$2587 to \$7370)	50	\$143 552 <sup>bcde</sup>	\$3372 (\$5859 to \$3264)	85	\$369 025 <sup>bc</sup>	\$4570 (\$2430 to \$6711)	59	\$160 648 <sup>bcdf</sup>	\$3372 (\$886 to \$5859)
Laceration wound	111	\$1 444 475 <sup>acdef</sup>	\$12204 (\$9375 to \$15 033)	18	\$3 191 163 <sup>bcdef</sup>	\$14 964 (\$4017 to \$25 911)	15	\$13 623 <sup>bcde</sup>	\$1135 (\$124 to \$2394)	17	\$367 389 <sup>bcdef</sup>	\$21 904 (\$6 792 to \$37 016)	14	\$260 190 <sup>b</sup>	\$16 809 (\$1532 to \$44 151)
Gradual onset	20	\$4805.4 <sup>a</sup>	\$2517 (\$479 to \$4 555)	17	\$50 110 <sup>a</sup>	\$2960 (\$958 to \$4422)	0	\$0	to	15	\$16 753	\$1396 (\$275 to \$3067)	15	\$8474	\$698 (\$371 to \$2 766)
Deathness	17	\$76 279	\$5070 (\$457 to \$22 598)	15	\$28 995 <sup>a</sup>	\$1867 (\$338 to \$11 073)	16	\$22 660 <sup>a</sup>	\$2382 (\$139 to \$4904)	12	\$63 390	\$834 (\$8 to \$4285)	6	\$12 099 <sup>a</sup>	\$2017 (\$1629 to \$2404)
Dental injuries	12	\$4804.5 <sup>ac</sup>	\$4004 (\$1200 to \$6807)	21	\$1 38 528 <sup>bc</sup>	\$6909 (\$5582 to \$8234)	4 <sup>a</sup>	\$3904	\$1301 to	3 <sup>a</sup>	\$5124	\$1 708 to	6	\$7742	\$2581 to
Hernia	16	\$76 586 <sup>a</sup>	\$4381 (\$548 to \$24 311)	15	\$55 299 <sup>a</sup>	\$1916 (\$224 to \$9059)	0	\$0	to	6	\$10 535	\$1756 (\$119 to \$5631)	0	\$0	to
Amputation/enucleation	9	\$5973 <sup>a</sup>	\$663 (\$22 to \$1304)	3 <sup>a</sup>	\$3789	\$1263 to	0	\$0	to	0	\$0	to	0	\$0	to
Non-occupational to occupational	9	\$9224	\$1024 (\$484 to \$1564)	3 <sup>a</sup>	\$3787	\$1262 to	0	\$0	to	6	\$17 927	\$2988 (\$489 to \$6465)	0	\$0	to
Foreign body	25226 <sup>bcdef</sup>	\$267 359 440 <sup>acdef</sup>	\$10582 (\$10 142 to \$11 022)	14240 <sup>bcdef</sup>	\$99 237 392 <sup>bcdef</sup>	\$6940 (\$6526 to \$7032)	11 748 <sup>bcdef</sup>	\$74 706 089 <sup>bcde</sup>	\$6330 (\$5664 to \$6995)	6517 <sup>bcdef</sup>	\$63 797 127 <sup>bcdef</sup>	\$9769 (\$8991 to \$10 547)	3072 <sup>bcde</sup>	\$24 258 835 <sup>bcde</sup>	\$7875 (\$6685 to \$9066)
All															
Serious injury claims															
Fracture/Dislocation	325	\$64 313 383 <sup>bcdef</sup>	\$209876 (\$201 451 to \$218 271)	0	\$0	to	9	\$320 399 <sup>bc</sup>	\$35589 (\$10 851 to \$179 694)	36	\$7 734 525 <sup>bcdef</sup>	\$222 350 (\$45 294 to \$399 405)	6	\$164 414 <sup>bc</sup>	\$568 (\$144 to \$2280)
Soft tissue injury	66	\$4 598 256 <sup>acde</sup>	\$136271 (\$122 821 to \$149 721)	15	\$6 081 75 <sup>bcde</sup>	\$47875 (\$37 799 to \$57 950)	0	\$0	to	20	\$1 470 389 <sup>bc</sup>	\$92568 (\$8 327 to \$116 810)	0	\$0	to
Concussion/Brain injury	31	\$3 176 880 <sup>cd</sup>	\$181 868 (\$125 174 to \$238 563)	0	\$0	to	0	\$0	to	34	\$3 413 723 <sup>ef</sup>	\$170 686 (\$134 903 to \$206 469)	9	\$282 600 <sup>bc</sup>	\$18 840 (\$14 839 to \$22 840)
Laceration wound	17	\$1 887 53 <sup>a</sup>	\$12583 (\$3506 to \$21 660)	0	\$0	to	0	\$0	to	0	\$0	to	0	\$0	to
Gradual onset	15	\$51 8510 <sup>a</sup>	\$34568 (\$19 939 to \$49 197)	0	\$0	to	0	\$0	to	0	\$0	to	0	\$0	to
Dental injuries	0	\$0	to	0	\$0	to	0	\$0	to	14	\$752 537 <sup>a</sup>	\$8060 (\$893–38 013)	0	\$0	to
All	454 <sup>bcdef</sup>	\$72 795 782 <sup>bcde</sup>	\$167 353 (\$148 539 to \$186 168)	15 <sup>cd</sup>	\$6 081 75 <sup>bcde</sup>	\$47 875 (\$37 799 to \$57 950)	9 <sup>bc</sup>	\$320 399 <sup>bc</sup>	\$35 589 (\$10 851 to \$179 694)	104 <sup>bcdef</sup>	\$12 691 174 <sup>bcdef</sup>	\$90 393 to \$161 917)	15 <sup>bc</sup>	\$447 014 <sup>abcd</sup>	\$17 856 (\$8609 to \$21 102)

All costs are inflation adjusted to 2016 values; significant difference (P<0.05). (a), Across reporting years (2012–2016); (b), rugby union; (c), football; (d), netball; (e), rugby league; (f), cricket. NZD\$, New Zealand dollars.

(£5229 (95% CI £4966 to £5491))) per moderate-to-serious injury entitlement claims. The age groups differed by sport for the highest moderate-to-serious injury entitlement claims and costs. There were more moderate-to-serious injury entitlement claims for participants aged 20–24 years playing rugby union than football ( $t_{(4)}=37.6$ ;  $P<0.0001$ ), netball ( $t_{(4)}=-25.3$ ;  $P<0.0001$ ), rugby league ( $t_{(4)}=-24.1$ ;  $P<0.0001$ ) and cricket ( $t_{(4)}=-31.4$ ;  $P<0.0001$ ).

## DISCUSSION

This retrospective analytical review used detailed descriptive epidemiological data obtained from the ACC for 2012–2016 for rugby union, rugby league, cricket, netball and football. The information on injury claims and costs added to prior reports of ACC sport data such as the 2002–2007 analysis for rugby league injuries.<sup>13–18</sup> The total number of claims, and therefore total costs, are somewhat dependent on exposure. Therefore, the focus of our analysis was on the average cost per claim type, and the differences between sports, gender and years. The average cost per moderate-to-serious claim was NZD\$8248 (95% CI NZD\$6013 to NZD\$10 483) (£4296 (95% CI £3132 to £5460)), which was higher than the mean cost-per-claim (NZD\$7206 (£3753)) from a previous study.<sup>15</sup> This difference may be related to the inclusion of five compared with one sports code (rugby league) and/or the increased costs of medical care between the two studies (2002–2007 vs 2012–2016). However, the cost percentage increase was greater than the rate of inflation over the same period.

The mean cost per moderate-to-serious injury entitlement claim was similar for males and females across most of the sporting codes in the study. It was not unexpected that males recorded more injuries than females across most of the sporting codes as males represent the largest cohort of participants in cricket, football, rugby league and rugby union, whereas females represent the largest cohort of participants in netball.

Although concussions accounted for an average of  $2.5\% \pm 1.5\%$  of the moderate-to-serious injury entitlement claims and  $3.0\% \pm 2.2\%$  of costs, the average mean cost per claim (NZD\$7691 (95% CI NZD\$6943 to NZD\$8439) (£4006 (95% CI £3616 to £4395)) was among the highest mean costs per injury. The number of concussions increased when compared with previous work<sup>19</sup> on sports-related concussion, and the mean cost per moderate-to-serious and serious concussion injury entitlement claim was more (NZD\$11 651 vs NZD\$9,804 (£6068 vs £5106)) when compared for the respective sporting codes. The mean costs per moderate-to-serious and serious concussion injury entitlement claim decreased over the reporting period (2012 vs 2016) for some (rugby union: NZD\$11 653 to NZD\$9033 (£6069 vs £4704); netball: NZD\$13 065 vs NZD\$6516 (£6803 vs £3393)) but not all (football: NZD\$2929 vs NZD\$3466 (£1525 vs £1822); rugby league: NZD\$25 868 vs NZD\$30 073 (£13 470 vs £15 657); cricket: NZD\$14 333 vs NZD\$23 325 (£7462 vs £12 144)) of the sports codes included in the study. Future research should investigate whether the change in mean costs per concussion is reflective of the increased awareness of concussion in sports and efforts of sporting codes in addressing these injuries.

Increasing numbers of people older than 35 years, train for, and compete in, team and individual sporting activities.<sup>29–30</sup> It is accepted<sup>31</sup> that exercise can assist with preventing, or reducing, changes in structure and function of the body associated with ageing. Injuries to sports participants over 35 years can present a unique challenge to the sports medicine community with the

injuries occurring alongside age-related changes and underlying pathologies.<sup>32</sup> The introduction of the masters' level of sporting activities for those over 35 years has enabled people to continue on within their sporting activities. The finding that those aged over 35 years recorded 22.9% of the total moderate-to-serious injury entitlement claims and 23.7% of costs is similar to a previous study<sup>15</sup> and may be reflective of this participation level in these sports. Although there are increasing numbers of participants competing in older age level sport, there is a paucity of studies detailing the incidence of injuries specifically to masters or president's participation level in sports. Research into this participation level in all sports is warranted to identify the risks and injury incidence that occur.

## Limitations

Most claims (792 424; 92.8%) reflected the number of injuries that resolved without further medical assistance. Data gathered through the ACC system should not be seen as being reflective of the total incidence of injuries from participation in these sporting codes in New Zealand.<sup>17</sup> The results exclude participants in these sporting codes who do not make an injury entitlement claim for more minor injuries.<sup>17</sup> Despite this, the results do highlight the number of injuries and their associated costs over a 5-year recording period that required medical assistance. There was no indication as to whether the injury claims recorded were for new, recurrent or exacerbation of previous injuries within the different sporting codes. The terms 'moderate-to-serious' and 'serious' are not a reflection of the severity classification of the injury, more the accounting terms applied by ACC to the costs involved with the rehabilitation of the injury. The moderate-to-serious claims recorded may not necessarily have been lodged or the accident have occurred, during the same period reported. Moderate-to-serious claims are recorded if there has been any entitlement received during the life of the claim and they are backdated to the day the claim was lodged. If there were to be future entitlements, then the data reported here would change accordingly.

## CONCLUSION

Rugby union featured prominently as the highest total number and costs associated with injury, likely due to the popularity of the sport, as well as the impact nature of the sport. Accurate sport exposure data are needed to enable injury risk calculations.

### What are the findings?

- ▶ Rugby union and rugby league have the most moderate-to-serious injury entitlement claims, total costs and highest mean cost for sporting injury in New Zealand.
- ▶ The mean cost per claims has increased from NZD\$7206 (£3749) (2002–2007) to NZD\$8248 (95% CI NZD\$6013 to NZD\$10 483) (£4490 (95% CI £3127 to £5460) (2012–2016); this percentage increase was 12% greater than the rate of inflation.
- ▶ The average cost per moderate-to-serious injury entitlement claims were similar in most sporting codes for male and female participants.
- ▶ Concussion injury entitlement claims provided the highest average cost of moderate-to-serious injuries recorded.
- ▶ Participants in the over 35 years age group recorded nearly a quarter of the total moderate-to-serious injury entitlement claims (23%) and costs (24%).

It is clear that an injury recorded by a healthcare provider when an injury is seen in New Zealand, and captured by the ACC recording system, does not fully describe the true cost of such injuries. However, it does identify the number of injuries that are moderate-to-serious, or serious, enough to warrant medical assistance.

**Contributors** 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 (DK; PAH; NH); (ii) acquisition of data (NH; DK; PAH); (iii) analysis and interpretation of data (DK, PAH, NH, CC, CG, TC); (iv) participated in drafting of the manuscript (DK, PAH, NH, CC, CG, TC); (v) critical revision of the manuscript for important intellectual content (DK, PAH, NH, CC, CG, TC).

**Funding** This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent** Not required.

**Ethics approval** Ethical consent was sought from the central region Health and Disability Ethics Committee (HDEC), but was not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

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