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Concordance between sentinel and subsequent injuries: A prospective study of injured New Zealanders

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ABSTRACT

Objectives: To describe: 1) settings, activities and types of injuries for an 'initial' (sentinel) injury and subsequent injuries over 24 months, and 2) concordance between sentinel and subsequent injury events.
Methods: Participants (n = 2856) were recruited to the Prospective Outcomes of Injury Study (POIS) following their sentinel injury event, an injury event resulting in an Accident Compensation Corporation (ACC) entitlement claim. Subsequent injuries were those from additional ACC claims in the following 24 months. Injury settings, activities and types were from electronic ACC claims data. The risks of having a subsequent injury of the same type as the sentinel injury were estimated.
Results: Overall, 1653 (58%) participants had 3444 subsequent injury events in 24 months, resulting in 4470 injury diagnoses. Twenty one percent had at least one subsequent injury event of the same type as their sentinel injury; 33% with a spine sprain/strain had at least one subsequent spine sprain/strain. Many participants had at least one subsequent injury event at same setting (26%) as their sentinel injury; of note, 36% of participants whose sentinel injury occurred at home had at least one subsequent injury at home. Seventeen percent of participants had at least one subsequent injury involving the same activity as their sentinel injury; 28% of those whose sentinel injury was a result of contact in sport had at least one subsequent injury also involving sport.
Conclusions: Subsequent injuries among people presenting to healthcare providers are common. Greater emphasis should be placed on maximising such healthcare provider contact as an injury prevention opportunity.

Introduction

Subsequent injury events, among people that have already been injured, are an important component of the overall injury burden [1–5]. In the 2016/17 year, New Zealand's universal no-fault injury insurer, the Accident Compensation Corporation (ACC), received nearly 2 million injury claims [6]. As New Zealand's population in 2016 was only 4.7 million [7], this suggests some individuals are likely to be experiencing multiple injury events resulting in multiple injury claims over time. We have previously reported that our study of 2856 injured New Zealanders found that 58% had at least one subsequent injury event in the two years following an injury involving an ACC entitlement claim (described in this paper as the sentinel injury), with a substantial proportion (31%) having more than a single subsequent injury event during this time [8]. Not only do subsequent injuries have a high incidence, they can also be more costly and lead to greater disability compared to earlier injuries [1,3]. In those studies reasons for this have not been examined empirically however it has been hypothesised these may include aspects such as incomplete rehabilitation of the initial injury or the nature of the injuries themselves [1]. To date, most studies about subsequent injury have limited analyses to specific injury types, settings, or populations. For example, studies have exclusively focused on paid workers [4,9], athletes [10,11] or elderly populations [12,13], whereas others have examined particular types of subsequent injury such as hamstring strains [14,15]. Expanding the investigation of subsequent injuries to broader injury populations and settings is important as there may be particular aspects that transcend specific populations and types of injury.

Determining patterns in subsequent injuries is complex and multifactorial, and characteristics of an injury may affect subsequent injuries. It is well documented that subsequent injuries are often of the same type as prior injuries among athletes [16–19].

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However, recent studies have also shown an increase in subsequent lower extremity injuries for athletes who experienced a previous concussion injury [20–22]. In workers, injuries such as surface wounds [23] and traumatic musculoskeletal injuries [4] have been associated with an increased likelihood of subsequent injuries of any type. A retrospective analysis of trauma patients in Canada showed that among adults with repeated hospitalisation for injury, 75% of their subsequent injuries occurred as a result of the same mechanism (for example motor vehicle, falls, assault) as their initial presentation [24].

The aim of this paper is to examine a general injury cohort over a period of 24 months to: (1) describe the settings in which sentinel and subsequent injuries occurred, the activities being undertaken at the time of these injury events, and the types of injuries incurred, and (2) explore the concordance between sentinel and subsequent injury events in terms of their settings, activities, and types of injuries incurred.

Methods

Participants

The Subsequent Injury Study (SInS) protocol has been published previously [25]. In SInS, data were combined from interviews, ACC administrative data, and the National Minimum Dataset (NMDS) of hospital discharges. Interview data were previously collected as part of the Prospective Outcomes of Injury Study (POIS) [26]. POIS participants were aged between 18 and 64 years and were from five geographic regions in New Zealand. POIS participant recruitment has been extensively described previously with 2856 (59%) of the 4881 contactable potential participants completing the first interview [26]. Interviews were undertaken, on average, three, 12 and 24 months following an injury involving an ACC entitlement claim (a claim type for injuries likely to require income compensation for one or more weeks away from paid employment or other longer-term rehabilitative assistance) [6,26]. The injury event that led to participants' recruitment to POIS is hereafter referred to as the 'sentinel injury event.' For each participant, interview data was linked with ACC data relating to the sentinel injury event and to any other ACC claim with a date of injury in the 24 months following the sentinel injury event ('subsequent injury events'). Using the NMDS, injuries involving hospitalisation within seven days of the sentinel or subsequent injury events were identified. Ethical approval was obtained from the New Zealand Health and Disability Multi-Region Ethics Committee (MEC/07/07/093).

Variables

Although all sentinel injury events were ACC entitlement claims, subsequent injury events included all ACC claim types: 'entitlement claims', 'medical fees only claims' (no additional rehabilitation support), 'other claims' (e.g. those involving lump sum payments for permanent disability) and 'unclassified' (e.g. those where funding was associated with a District Health Board's bulk funding).

Information about settings where the sentinel and subsequent injuries occurred was derived from ACC's recording of participants' descriptions of injury 'scene' and classified as: commercial/industrial, farm, home, medical treatment, recreation/sports, road/street and school. 'Other' included injuries that occurred at settings not otherwise classified such as residential care facilities, public entertainment areas, and at sea. Activities being undertaken at the time of the injury were derived from ACC's recording of 'activity prior' and classified as: ascending/descending/on/off/in/out, bending/reaching/turning, contact in sport, driving/riding, fighting/assault, jumping/landing, lifting/loading/pulling, preparing/eating food, using machinery/tools, and walking/running. A further category of 'other' included activities not otherwise classified such as working at a height (e.g. on a ladder or roof), various household work activities, and some sporting/recreational activities such as dancing, skipping, skiing, and skateboarding.

Injury type was derived from diagnoses collected by ACC as either Read codes [27], International Classification of Diseases (ICD)-9, or ICD-10 codes. All diagnoses were either originally recorded as ICD-10 codes or were mapped to ICD-10 codes [28]. The most common combinations of injury nature and body region were used to determine 12 injury type variables: intracranial; lower and upper extremity fracture; lower, upper and spine dislocation/sprain/strain; lower and upper extremity open wound; head/neck, lower and upper extremity superficial; and other region/nature. These 12 variables were used to capture all injury diagnoses resulting from both the sentinel and subsequent injury events. For instance, a participant could have a sentinel injury event such as a fall that resulted in multiple injury types, e.g. a wrist fracture and an ankle sprain. This would be coded as 'yes' for the upper limb fracture and for lower extremity dislocation/sprain/strain sentinel injury variables, and 'no' for the remaining ten sentinel injury type variables. This same participant could also have had one or more subsequent injury events during the 24 month follow-up period; each subsequent event potentially involving more than one type of injury.

Analyses

The distribution of sentinel and subsequent injury settings, activities and types have been described using frequencies, percentages and 95% confidence intervals (CIs). Contingency tables have been used to present relationships between sentinel injury and subsequent injury settings, activities, and injury types for participants with at least one subsequent injury event. Relative risks and 95% CIs have been used to estimate increased risk of subsequent injury types given sentinel injury types. Analyses were undertaken using Stata v.14 [29] and SPSS v.24 [30].

Results

The 2856 participants were aged 18–64 years (inclusive) at the time of their sentinel injury; 61% percent were male, 68% reported New Zealand European ethnicity, and 20% reported Māori ethnicity (New Zealand's indigenous population) [26]. Each participant had one sentinel injury event (as this led to their POIS recruitment). These 2856 sentinel injury events resulted in 4249 injury diagnoses. In the 24 months following their sentinel injury, 1653 (58%) participants had at least one subsequent injury event resulting in an ACC injury claim [8]. In total, these 1653 participants had 3444 subsequent injury events in 24 months (Table 1) involving 4470 injury diagnoses (as each injury event could involve more than one injury diagnosis).

Sentinel and subsequent injury settings

Table 1 describes the settings of participants' sentinel and subsequent injury events. Sentinel and subsequent injury events followed a similar pattern with the highest percentage occurring in the home, followed by commercial/industrial and recreation settings. Seven hundred and fifty four (26%) of the 2856 participants had at least one subsequent injury that occurred in the same setting as their sentinel injury. By setting, this ranged from 7% for injuries in schools to 36% for injuries at home. After injuries in the home, the setting with the next highest concordance between sentinel and subsequent injury events was recreation/

Table 1
Settings of sentinel and subsequent injury events.

Setting	Sentinel injury events (N = 2856)[a]		Subsequent injury events (N = 3444)[b]		Participants with at least one subsequent injury at the same setting as their sentinel injury		
	n	(column %)	n	(column %)	n	(row %)[c]	(95% Confidence Interval)
Commercial/Industrial	602	(21)	651	(19)	156	(26)	(22, 30)
Farm	93	(3)	71	(2)	22	(24)	(15, 34)
Home	845	(30)	1221	(35)	300	(36)	(32, 39)
Medical treatment	9	(0)	18	(1)	2	(22)	(3, 60)
Recreation/Sports	575	(20)	664	(19)	177	(31)	(27, 35)
Road/Street	400	(14)	259	(8)	54	(14)	(10, 17)
School	27	(1)	14	(0)	2	(7)	(0, 24)
Other[d]	285	(10)	291	(8)	40	(14)	(10, 19)
Not obtainable	20	(1)	255	(7)	1	(5)	(0, 25)
Total	2856	(100)	3444	(100)	754	(26)	(25, 28)

[a] Each of the 2856 participants had one sentinel injury event (the injury event which led to their recruitment into the study).
[b] Participants could have more than one subsequent injury event during the 24 months of follow-up.
[c] The denominator used to calculate row percentages was the number of participants who experienced their sentinel injury at that particular setting.
[d] This includes injuries that occurred at a variety of settings not otherwise classified including residential care facilities, public entertainment areas and at sea.

Table 2
Comparison of settings of sentinel and subsequent injury events for participants with at least one subsequent injury (N = 1653)[a].

Sentinel injury setting	Participants with at least one subsequent injury		At least one subsequent injury in this setting (n, row %)[b]															
			Commercial/ industrial	Farm		Home		Medical treatment		Recreation/ sports		Road/ street		School		Other		Not obtainable	
	n	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Commercial/Industrial	345	**156**	**(45)**	8	(2)	186	(54)	4	(1)	41	(12)	42	(12)	2	(1)	51	(15)	31	(9)
Farm	59	14	(24)	**22**	**(37)**	27	(46)	1	(2)	8	(14)	5	(8)	0	(0)	5	(8)	8	(14)
Home	486	144	(30)	7	(1)	**300**	**(62)**	4	(1)	75	(15)	59	(12)	4	(1)	68	(14)	50	(10)
Medical treatment	8	2	(25)	0	(0)	6	(75)	**2**	**(25)**	1	(13)	0	(0)	0	(0)	1	(13)	1	(13)
Recreation/Sports	358	73	(20)	1	(0)	160	(45)	2	(1)	**177**	**(49)**	58	(16)	3	(1)	54	(15)	61	(17)
Road/Street	197	49	(25)	3	(2)	106	(54)	2	(1)	39	(20)	**54**	**(27)**	2	(1)	27	(14)	21	(11)
School	15	1	(7)	0	(0)	10	(67)	1	(7)	3	(20)	2	(13)	**2**	**(13)**	2	(13)	2	(13)
Other[c]	172	45	(26)	10	(6)	91	(53)	1	(1)	37	(22)	19	(11)	1	(1)	**40**	**(23)**	20	(12)
Not obtainable	13	4	(31)	2	(15)	8	(62)	0	(0)	1	(8)	1	(8)	0	(0)	2	(15)	1	(8)
Total	1653	488	(30)	53	(3)	894	(54)	17	(1)	382	(23)	240	(15)	14	(1)	250	(15)	195	(12)

[a] Bolded type within the table indicates those that had at least one subsequent injury at the same setting as their sentinel injury.
[b] The denominator used to calculate row percentages was the number of participants who had their sentinel injury in that particular setting and who went on to have at least one subsequent injury. Participants could have more than one subsequent injury event in a particular setting.
[c] This includes injuries that occurred at a variety of settings not otherwise classified including residential care facilities, public entertainment areas and at sea.

Table 3
Activities undertaken at the time of sentinel and subsequent injury events.

Activity	Sentinel injury event (N = 2856)[a]		Subsequent injury events (N = 3444)[b]		Participants with at least one subsequent injury with the same activity involved as the sentinel injury		
	n	(column %)	n	(column %)	n	(row %)[c]	(95% CI)
Ascending/Descending/On/Off/In/Out	308	(11)	221	(6)	28	(9)	(6, 13)
Bending/Reaching/Turning	96	(3)	105	(3)	8	(8)	(4, 16)
Contact in sport	148	(5)	210	(6)	42	(28)	(21, 36)
Driving/Riding	317	(11)	188	(5)	37	(12)	(8, 16)
Fighting/Assaulted	90	(3)	70	(2)	8	(9)	(4, 17)
Jumping/Landing	65	(2)	46	(1)	4	(6)	(2, 15)
Lifting/Loading/Pulling	353	(12)	528	(15)	75	(21)	(17, 26)
Preparing/Eating food	25	(1)	48	(1)	1	(4)	(0, 20)
Using machinery/tools	186	(7)	195	(6)	25	(13)	(9, 19)
Walking/Running	571	(20)	571	(17)	108	(19)	(16, 22)
Other[d]	560	(20)	555	(16)	105	(19)	(16, 22)
Not obtainable	137	(5)	707	(21)	33	(24)	(17, 32)
Total	2856	(100)	3444	(100)	474	(17)	(15, 18)

[a] Each of the 2856 participants had one sentinel injury event (the injury event which led to their recruitment into the study).
[b] Participants could have more than one subsequent injury event during the 24 months of follow-up.
[c] Denominator used was the number of participants who had their sentinel injury while undertaking that particular activity.
[d] This included a variety of activities such as working at a height (ladder/roof); various household work activities, e.g. sweeping floor, getting clothes off line, cleaning car; and various sporting/recreational activities, e.g. dancing, skipping, skiing, skateboarding, catching/kicking ball.

sports; of the 575 participants whose sentinel injury event occurred in a recreation/sports setting, 177 (31%) also had at least one subsequent injury event in this setting.

Restricting analyses to those who had at least one subsequent injury (n = 1653) within 24 months after their sentinel injury (Table 2), the sentinel injury setting for which the greatest number of people went on to have at least one subsequent injury (at any setting) was the home (n = 486), followed by recreation/sports (n = 358) and commercial/industrial settings (n = 345). Of the 486 participants with a sentinel injury in the home and at least one subsequent injury, 62% had at least one subsequent injury also at home, 30% had at least one commercial/industrial subsequent injury and 15% had at least one recreation/sports subsequent injury. Of the 358 participants with a recreation/sports sentinel injury and at least one subsequent injury, 49% had at least one subsequent injury also in that setting and 45% had at least one subsequent injury at home. Of the 345 participants with a commercial/industrial sentinel injury and at least one subsequent injury, 45% had at least one subsequent injury also in that setting while 54% had at least one subsequent injury at home.

Activities associated with sentinel and subsequent injuries

Table 3 presents activities involved with sentinel and subsequent injury events for all 2856 participants. The specific activities most frequently involved with both sentinel and subsequent injury events were 'walking/running' and 'lifting/loading/pulling' (Table 3). Overall, 474 (17%) of the 2856 participants had at least one subsequent injury while performing the same type of activity as when their sentinel injury event occurred. The specific activities where participants most commonly had at least one subsequent injury caused by the same activity as their sentinel injury were contact in sport (28%), 'lifting/loading/pulling' (21%), and 'walking/running' (19%).

Of participants with at least one subsequent injury (n = 1653), walking/running was the most common specific activity being undertaken at the time of the sentinel injury (n = 309; Table 4). Of these 309 participants, 35% had at least one subsequent injury that also occurred while walking/running. Of the 229 participants with a lifting/loading/pulling sentinel injury and at least one subsequent injury, 33% had at least one subsequent injury also related to lifting/loading/pulling.

Sentinel and subsequent injury type

Participants' sentinel injuries most commonly involved lower extremity dislocation/sprain/strain (23%), or upper or lower extremity fracture (both 17%) (Table 5). There was variation in the occurrence of 'any' subsequent injury according to the type of sentinel injury; among those with at least one lower extremity fracture sentinel injury, 50% had at least one subsequent injury (of any type), whereas among those with a head and neck superficial injury, 63% had at least one subsequent injury. Spine sprain/strains had the highest proportion (33%) of participants with at least one subsequent injury of the same injury type as their sentinel injury. This was followed by lower and upper extremity dislocation/sprain/strains (27% and 25%, respectively).

Overall, 21% (n = 613) of participants had at least one subsequent injury of the same injury type as their sentinel injury. Of those with a superficial lower extremity sentinel injury, 4% (n = 4 of 113) had at least one subsequent injury of this type compared to only 1% (n = 16 of 1540) of those that did not have a superficial lower extremity sentinel injury (Table 6). This means participants whose sentinel injury event involved at least one superficial lower extremity injury were 3.4 times as likely (95% CI 1.2, 10.0) to have at least one subsequent injury of the same type compared to those

Table 4
Comparison of activities undertaken at the time of sentinel and subsequent injury events for participants with at least one subsequent injury (N = 1653).

Sentinel injury activity	Participants with at least one subsequent injury	At least one subsequent injury associated with this activity, n (%)[b]																											
		Ascending/ Descending /On/Off/In/Out		Bending/ Reaching/ Turning		Contact in sport		Driving/ Riding		Fighting/ Assaulted		Jumping/ Landing		Lifting/ Loading/ Pulling		Preparing/ Eating food		Using machinery/ tools		Walking/ Running		Other		Not obtainable	
	n	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Ascending/Descending/On/Off/ In/Out	158	[a]**28**	**(18)**	10	(6)	1	(1)	15	(9)	3	(2)	1	(1)	38	(24)	3	(2)	14	(9)	51	(32)	40	(25)	44	(28)
Bending/Reaching/Turning	59	8	(14)	**8**	**(14)**	2	(3)	3	(5)	2	(3)	1	(2)	21	(36)	4	(7)	6	(10)	11	(19)	15	(25)	18	(31)
Contact in sport	102	5	(5)	4	(4)	**42**	**(41)**	4	(4)	6	(6)	6	(6)	18	(18)	0	(0)	5	(5)	35	(34)	34	(33)	57	(56)
Driving/Riding	170	15	(9)	6	(4)	8	(5)	**37**	**(22)**	5	(3)	5	(3)	38	(22)	7	(4)	21	(12)	42	(25)	48	(28)	43	(25)
Fighting/Assaulted	55	7	(13)	3	(5)	1	(2)	4	(7)	**8**	**(15)**	2	(4)	13	(24)	2	(4)	7	(13)	16	(29)	14	(25)	24	(44)
Jumping/Landing	35	4	(11)	0	(0)	3	(9)	5	(14)	1	(3)	**4**	**(11)**	6	(17)	0	(0)	1	(3)	9	(26)	9	(26)	7	(20)
Lifting/Loading/Pulling	229	34	(15)	19	(8)	5	(2)	23	(10)	6	(3)	5	(2)	**75**	**(33)**	4	(2)	29	(13)	48	(21)	66	(29)	67	(29)
Preparing/Eating food	11	1	(9)	3	(27)	0	(0)	1	(9)	1	(9)	0	(0)	1	(9)	**1**	**(9)**	1	(9)	2	(18)	2	(18)	4	(36)
Using machinery/tools	114	11	(10)	7	(6)	8	(7)	8	(7)	4	(4)	3	(3)	42	(37)	0	(0)	**25**	**(22)**	24	(21)	30	(26)	35	(31)
Walking/Running	309	39	(13)	18	(6)	15	(5)	22	(7)	6	(2)	6	(2)	74	(24)	11	(4)	24	(8)	**108**	**(35)**	75	(24)	106	(34)
Other[c]	327	39	(12)	18	(6)	20	(6)	29	(9)	20	(6)	11	(3)	76	(23)	11	(3)	38	(12)	110	(34)	**105**	**(32)**	111	(34)
Not obtainable	84	7	(8)	3	(4)	7	(8)	4	(5)	3	(4)	1	(1)	21	(25)	3	(4)	3	(4)	25	(30)	23	(27)	33	(39)
Total	1653	198	(12)	99	(6)	112	(7)	155	(9)	65	(4)	45	(3)	423	(26)	46	(3)	174	(11)	481	(30)	461	(28)	549	(33)

[a] Bolded type indicates participants that had at least one subsequent injury resulting from the same activity as their sentinel injury.
[b] The denominator used to calculate row percentages was the number of participants whose sentinel injury was of that particular activity that had at least one subsequent injury. Participants could have more than one subsequent injury event associated with a particular activity.
[c] This included a variety of activities such as working at height (ladder/roof); various household work activities, e.g. sweeping floor, getting clothes off line, cleaning car; various sporting/recreational activities, e.g. dancing, skipping, skiing, skateboarding, catching/kicking ball.

Table 5
Types of injury resulting from sentinel and subsequent injury events.

Injury type	Participants with at least one sentinel injury of this type (N = 2856)[a]		Participants with any subsequent injury (n = 1653)[a]		Participants with at least one subsequent injury of the same injury type as the sentinel injury (n = 613)[a]	
	n	(column %)[b]	n	(row %)[c]	n	(row %)[c]
Head/neck/spine						
Intracranial	105	(4)	62	(59)	4	(4)
Head/neck superficial	102	(4)	64	(63)	5	(5)
Spine sprain/strain	448	(16)	274	(61)	148	(33)
Upper extremity						
Fracture	493	(17)	276	(56)	25	(5)
Dislocation/sprain/strain	389	(14)	237	(61)	98	(25)
Open wound	171	(6)	103	(60)	28	(16)
Superficial	140	(5)	82	(59)	4	(3)
Lower extremity						
Fracture	473	(17)	235	(50)	15	(3)
Dislocation/sprain/strain	659	(23)	384	(58)	175	(27)
Open wound	114	(4)	58	(51)	9	(8)
Superficial	192	(7)	113	(59)	4	(2)
Other regions/nature	481	(17)	270	(56)	123	(26)

[a] This is the number of participants; people could have more than one injury type therefore the sum of the column is greater than the number of participants.
[b] The denominator used to calculate column percentages was the total number of participants (N = 2856).
[c] The denominator used to calculate row percentages was the total number of participants with this sentinel injury type, e.g. 105 for intracranial.

Table 6
Comparison of types of injury resulting from sentinel and subsequent injury events (N = 1653).

Injury type	Sentinel injury		Participants with at least one subsequent injury of the same injury type (N = 613)			
		N	N	(Row %)	Relative Risk	(95% CI)
Head/Neck/Spine						
Intracranial	yes	62	4	(6)	2.6	(1.0, 7.1)
	no	1591	39	(2)		
Head/neck superficial	yes	64	5	(8)	1.1	(0.5, 2.6)
	no	1589	115	(7)		
Spine sprain/strain	yes	274	148	(54)	1.5	(1.3, 1.7)
	no	1379	490	(36)		
Upper Extremity						
Fracture	yes	276	25	(9)	2.0	(1.3, 3.1)
	no	1377	63	(5)		
Dislocation/sprain/strain	yes	237	98	(41)	1.8	(1.5, 2.2)
	no	1416	320	(23)		
Open wound	yes	103	28	(27)	1.9	(1.4, 2.7)
	no	1550	217	(14)		
Superficial	yes	82	4	(5)	1.4	(0.5, 3.7)
	no	1571	56	(4)		
Lower Extremity						
Fracture	yes	235	15	(6)	1.8	(1.1, 3.2)
	no	1418	49	(3)		
Dislocation/sprain/strain	yes	384	175	(46)	1.7	(1.4, 1.9)
	no	1269	350	(28)		
Open wound	yes	58	9	(16)	2. 4	(1.3, 4.6)
	no	1595	102	(6)		
Superficial	yes	113	4	(4)	3.4	(1.2, 10.0)
	no	1540	16	(1)		
Other regions/nature	yes	270	123	(46)	1.0	(0.9, 1.2)
	no	1383	602	(44)		

whose sentinel injury did not involve this type of injury. Participants with an intracranial sentinel injury were 2.6 times as likely (95% CI 1.0, 7.1) to have a subsequent intracranial injury compared to participants whose sentinel injury did not involve this type of injury.

Discussion

All participants in this study had been in contact with healthcare providers for their sentinel injury event, yet a substantial proportion had at least one subsequent injury in either the same setting (26%), involving the same type of activity (17%) or of the same injury type (21%) as their sentinel injury event in the following 24 months. If the occurrence of subsequent injuries were able to be reduced by interventions implemented when people came to the attention of healthcare providers, the overall burden of injury would be reduced.

The setting with the highest concordance between sentinel and subsequent injuries was the home; 36% of participants with a sentinel injury at home had at least one subsequent injury at home in the following 24 months (Table 1). People's homes have been widely recognised as a common setting for injury [31,32].

Importantly, this current study highlights the recurrent nature of injury events in this setting. A 2011 Cochrane Review [33] found insufficient evidence for the effect of home environment modifications on injury reduction, however, more recently a study of home modifications in New Zealand reported a 26% reduction in injuries relating to falls in the home [34].

When identifying opportunities to prevent subsequent injury, it may be useful to focus on people with injuries caused by contact in sport and lifting/loading/pulling activities; 28% and 21% of people presenting with sentinel injuries related to these activities, respectively, had at least one subsequent injury involving the same activity in the following 24 months. There have been many studies examining the prevention of sports injuries, for example a 2014 systematic review included 68 randomised controlled trials and found evidence for specific training programs and the use of external joint supports and insoles [35]. Likewise, manual handling (which includes lifting, loading and pulling) has been recognised as a risk factor for injury and musculoskeletal disorders [36].

Spine sprains/strains (which includes the cervical, thoracic and lumbar spine regions) had the highest concordance between sentinel and subsequent injury types. This finding was not surprising as previous studies estimate 24–80% of people present with recurrent low back pain symptoms within a year [37].

A key strength of this study is the inclusion of a broad range of injury types, settings, and activities and injury claim types. Examining this 'general injury' population is important in understanding the 'big picture' of subsequent injury. By not being limited to one particular injury setting, activity or type, this study has allowed us to examine the overall distribution of these aspects of subsequent injuries. This is applicable in a 'real-world' situation where healthcare professionals, and in New Zealand ACC, are involved with injuries related to a range of settings, activities and types and highlights areas where injury prevention initiatives might have the greatest impact on subsequent injuries. In addition, rather than being hampered by interview non-response over time, this study used administrative claims data to obtain 24 months of subsequent injury information for all 2856 participants. There were, however, some limitations of the study. Although claims data was available for all participants, the nature of the categorisation of some data (for example, some settings or activities occurred infrequently and did not warrant their own separate category) meant that some variables included a substantial proportion for whom that variable was categorised as 'Other' or 'Unobtainable.' Additionally, the sentinel injury events involved ACC entitlement claims, whereas subsequent injury events included all ACC claim types. While the concordance between sentinel and subsequent injuries may have been different had they included the same types of ACC claims, this approach allowed the investigation of all ACC subsequent injuries within a 24-month time period. Furthermore, the sentinel injury, while representing an injury event that was likely to require at least a week off work or to require rehabilitation assistance, may itself have been a 'subsequent injury event' for some participants. For example, 4% of participants had a previous entitlement claim injury in the year prior to their sentinel injury event. However, it would be difficult to identify and follow a 'never injured' population, hence our starting with readily identifiable (for both investigation and potential interventions) ACC entitlement claimants.

Conclusion

In conclusion, a substantial proportion of people with injuries that come to the attention of ACC case managers or health professionals (in this case via an ACC entitlement claim) are likely to have subsequent injuries in the same setting, involving the same activity or of the same injury type as their sentinel injury. This highlights an important opportunity for injury prevention. Findings suggest that injuries occurring in the home or in commercial/industrial settings may be particularly important settings to consider, as well as people presenting with injuries caused by contact in sport or lifting/loading/pulling. Due to New Zealand's unique no-fault injury insurance scheme (the ACC) the generalisability of these study results to other countries is less clear but it is likely that opportunities for prevention of subsequent injuries exist in the healthcare settings during or after treatment for sentinel injuries. Further research is currently underway aiming to identify predictors of subsequent injuries in order to contribute to the development and implementation of effective subsequent injury prevention strategies.

Contributors

HH and DA led the preparation of this paper. DA wrote the first draft of the paper; HH wrote subsequent drafts. DA and GD undertook the analyses. SD and HH lead the Subsequent Injury Study project. All authors contributed to the design of the study, the interpretation of the data and writing and editing of the manuscript. All authors have read and approved the final manuscript.

Ethics

Ethical approval was obtained from the New Zealand Health and Disability Multi-Region Ethics Committee (MEC/07/07/093).

Conflicts of interest

None.

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