Prevalence and Predictors of Disability 24-Months after Injury for Hospitalised and Non-Hospitalised Participants: Results from a Longitudinal Cohort Study in New Zealand

Sarah Derrett¹,⁴, Suzanne Wilson¹, Ari Samaranayaka¹, John Langley¹, Emma Wyeth², Shanthi Ameratunga³, Rebecca Lilley¹, Gabrielle Davie¹, Melbourne Mauiliu¹

¹ Injury Prevention Research Unit, Department of Preventive and Social Medicine, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand. ² Te Roopu Rangahau Hauora Māori a Ngāi Tahu (Ngāi Tahu Māori Health Research Unit), Department of Preventive and Social Medicine, Dunedin School of Medicine, University of Otago, Dunedin, New Zealand. ³ School of Population Health, Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand. ⁴ School of Health and Social Services, College of Health, Massey University, Palmerston North, New Zealand

Abstract

Introduction: Most studies investigating disability outcomes following injury have examined hospitalised patients. It is not known whether variables associated with disability outcomes are similar for injured people who are not hospitalised.

Aims: This paper compares the prevalence of disability 24 months after injury for participants in the Prospective Outcomes of Injury Study who were hospitalised and those non-hospitalised, and also seeks to identify pre-injury and injury-related predictors of disability among hospitalised and non-hospitalised participants.

Methods: Participants, aged 18–64 years, were recruited from an injury claims register managed by New Zealand’s no-fault injury compensation insurer after referral by health care professionals. A wide range of pre-injury socio-demographic, health and psychosocial characteristics were collected, as well as injury-related characteristics; outcome is assessed using the WHODAS. Multivariable models estimating relative risks of disability for hospitalised and non-hospitalised participants were developed using Poisson regression methods.

Results: Of 2856 participants, analyses were restricted to 2184 (76%) participants for whom both pre-injury and 24 month WHODAS data were available. Of these, 25% were hospitalised. In both hospitalised and non-hospitalised groups, 13% experience disability (WHODAS≥10) 24 months after injury; higher than pre-injury (5%). Of 28 predictor variables, seven independently placed injured participants in the hospitalised group at increased risk of disability 24 months after injury; eight in the non-hospitalised. Only four predictors (pre-injury disability, two or more pre-injury chronic conditions, pre-injury BMI≥30 and trouble accessing healthcare services) were common to both the hospitalised and non-hospitalised groups. There is some evidence to suggest that among the hospitalised group, Māori have higher risk of disability relative to non-Māori.

Conclusions: At 24 months considerable disability is borne, equally, by hospitalised and non-hospitalised groups. However, predictors of disability are not necessarily consistent between the hospitalised and non-hospitalised groups, suggesting caution in generalising results from one group to the other.

Introduction

Injuries are responsible for significant health burdens in terms of premature mortality from fatal injuries and disability to injury survivors. Recently, the Global Burden of Disease report from the World Health Organisation (WHO) revealed that reductions in the disability-adjusted life year (DALY) burden associated with communicable, maternal, neonatal, and nutritional disorders have been achieved, but that similar gains have not been demonstrated for injury [1]. Increasingly, the disability-related burden experienced by survivors of injury is the focus of attention from clinicians, policy-makers and researchers [2–5]. Nonetheless,
studies investigating outcomes resulting from a wide range of injury types are limited. Where studies of injury outcome have been reported, they are often restricted to recruiting people via hospitals; few studies have reported outcomes for injured people not admitted to hospital due to their injury, and even fewer have used recognised measures of disability outcome [3–9].

We have previously reported the prevalence of disability outcomes three months after injury for participants in the Prospective Outcomes of Injury Study (POIS) underway in New Zealand [9]. Proportionately more participants reported disability three months after their injury than before it, both for those who were hospitalised (34% versus 5% respectively) and those who were not (39% versus 5% respectively). We also found that only three of the 27 variables included in the multivariable models – pre-injury disability, BMI≥30 and injury severity – were independently associated with increased odds of disability three months after injury for both the hospitalised and non-hospitalised groups; other variables were also associated with increased odds of disability, but only among either the hospitalised group or the non-hospitalised group [9].

In this paper, we investigate whether the difference in risk factors observed three months after injury remains when longer-term outcomes are considered. POIS was developed with careful attention paid to the principles of the Treaty of Waitangi, a treaty of cession signed by representatives of Māori (New Zealand’s indigenous population; Māori comprise 15% of the total New Zealand population) and the British Crown in 1840 [10], to ensure that disability outcomes for Māori could be better understood [9,11]. Like many other indigenous populations throughout the world, Māori experience numerous health disparities compared to non-Māori; injury and disability are no exception. Despite concerns about health and disability disparities for Māori, and also Pacific peoples, having been identified within New Zealand, there is scant knowledge about injury-related disability outcomes for these populations [12,13].

This paper compares the prevalence of disability 24 months after injury for POIS participants who were hospitalised and those who were non-hospitalised, especially for participants reporting Māori or Pacific ethnicity. The paper also seeks to identify predictors of participants’ disability in terms of their pre-injury socio-demographic, disability, health and psychosocial and injury-related characteristics, to help inform future development of appropriate interventions.

Methods

The study was undertaken following approval from the New Zealand Health and Disability Multi-Region Ethics Committee (MEC/07/07/093). Following feedback from participants in the pilot study and to be inclusive of all people (including those with poor vision or limited literacy), and with the approval of the Ethics Committee, all participants granted oral consent to participate after receiving comprehensive information about the study. Oral consent was documented by interviewers, and all participants received copies of the consent form.

Study Participants

The design of POIS and the main characteristics of participants have been described previously [11,14–16]. In summary, potential participants were aged 18–64 years (inclusive) and lived in one of five geographical regions in New Zealand. Following referral by an accredited healthcare professional, participants had all been placed on an injury (entitlement claims) register at the Accident Compensation Corporation (ACC), New Zealand’s no-fault injury compensation insurer. Entitlement claimants have injuries serious enough to potentially require support, such as income compensation (if in paid employment), medical treatment and/or social and rehabilitation services; people with injuries resulting from self-harm or sexual assault were excluded from this study [14,17]. ACC sent letters about the study to 7873 entitlement claimants on behalf of the research team; of these, 4891 people were subsequently able to be contacted by the POIS research team; 2836 (59%) participated in their first interview between December 2007 and August 2009 [15]. This paper uses data collected at interviews held three months (median = 3.2; interquartile range, IQR = 2.5,4.2) and 24 months (median = 24.4; IQR = 24.1, 25.1) after injury.

Outcome

Disability outcome was measured using the brief WHO Disability Assessment Schedule (WHODAS II 12-item) [18]. Participants were asked to report WHODAS status over the 30 days before the 24 month interview. Scores are as described previously, with a possible range from 0–48 [9,19]. Participants were grouped as having ‘disability’ if their WHODAS score was ≥10, and as having ‘no (or lesser) disability’ if their score was <10 [9]. At the three month interview, participants also reported their pre-injury WHODAS status for the 30 days prior to their injury, permitting adjustment of disability outcome for pre-injury disability.

Hospitalisation

Data from POIS participants were probabilistically linked to a national database (the National Minimum Data Set) to identify participants admitted to hospital or treated at an Emergency Department for at least three hours, within seven days of the injury event, as described previously [9]. Those linked were classified as ‘hospitalised’ and those not as ‘non-hospitalised’.

Explanatory Variables

Explanatory variables were grouped according to pre-injury socio-demographic, pre-injury health and psychosocial, and injury-related, characteristics. These items have been described before, and are therefore only briefly summarised here [9].

Pre-injury socio-demographic characteristics. Participants reported socio-demographic characteristics at the time of the first interview including: age, sex, ethnicity, highest educational qualification and living arrangements, based on questions from the 2006 New Zealand Census [20]. All participants who reported ethnicities were categorised as ‘yes’ or ‘no’ for each of the Māori and Pacific ethnicity variables. People were considered Māori if they reported Māori as any of their ethnicities, and Pacific if they reported a Pacific ethnicity. If a participant reported both Māori and one or more Pacific ethnicities they were classified as ‘yes’ for Māori ethnicity and also as ‘yes’ for Pacific ethnicity. Ethnicities classified as ‘Pacific’ have been described previously, and included participants of Samoan, Cook Island Māori, Tongan and Nieuenean ethnicities [21]. Highest educational qualification was grouped as ‘no qualifications’, ‘secondary school’ (high-school) level or ‘post-secondary school’ qualifications (where these took three months or more to obtain). ‘Living arrangements’ were grouped as living: ‘alone’, ‘with non-family’ or ‘with family’ (including partner/spouse). People working full-time (≥30 hours per week) or part-time (<30 hours per week) were classified as ‘working for pay’; the remaining as ‘not working for pay’ [22]. Household income was categorised as ‘adequate’ if participants reported ‘just enough’, ‘enough’ or ‘more than enough’ total pre-injury household income
to meet their everyday needs; or ‘inadequate’ if they reported ‘not enough’ income [22].

Pre-injury health and psychosocial characteristics. Overall pre-injury ‘general health’ was rated on a five-point scale (‘excellent’, ‘very good’, ‘good’, ‘fair’ or ‘poor’) [23]. To assess pre-injury chronic conditions, participants reported whether they had been told by a doctor they had one, or more, of a list of 22 chronic illnesses or diseases (e.g. asthma, cancer, diabetes, depression or anxiety) that had lasted, or was expected to last, for more than six months [24]. Participants were defined as having a depressive-type episode if they responded affirmatively to either of two screening questions: that nearly every day, for a period of two weeks or more in the year before injury, they had felt ‘sad, blue or depressed’ or ‘loss of interest in things like work or hobbies or things they usually like to do for fun’ [25]. Participants who ‘strongly agreed’ or ‘agreed’ with a statement that ‘Overall, I expect more good things to happen to me than bad’ were categorised as ‘optimistic’ and compared with the rest [26]. ‘Self-efficacy’ was based on the General Self-Efficacy Scale [27]. A score ≤25 was classified as poor self-efficacy [9]. A single question from FACT-Sp (permission granted by www.facit.org) asked participants if they found ‘comfort in faith and spiritual beliefs’ [28].

Pre-injury ‘family involvement’ was assessed by asking whether family played a ‘very large’, ‘large’, ‘small’ or ‘very small’ part in participants’ lives [22]. Participants rated their overall satisfaction with ‘social relationships’ [9]. Those reporting they were ‘completely’ or ‘mostly’ satisfied were classified as ‘satisfied’; those reporting being ‘neither satisfied nor dissatisfied’, ‘mostly’ or ‘completely’ dissatisfied were classified as ‘not satisfied’. ‘Sense of community’ was assessed by asking participants to state whether they felt their neighbourhood’s ‘sense of community’ was ‘strong’, ‘very little’ or ‘something in-between’ [29].

Pre-injury levels of physical activity were assessed by asking the number of days in the seven-day period prior to injury they had engaged in either 30 minutes of moderate activity (including brisk walking) or 15 minutes of vigorous activity [30]. ‘Sleep’ was assessed by asking the number of nights per week that they (usually) had seven or more hours sleep [9]. Body Mass Index (BMI) was categorised as BMI<30 and BMI≥30 [9,31]. Pre-injury smoking was assessed by asking whether or not people smoke cigarettes regularly [20]. Participants were grouped into three ‘alcohol use’ categories according to their reported consumption in the year before injury using the brief Alcohol Use Disorders Identification Test (AUDIT-C) [9,32]. Participants were also asked about ‘recreational drug use’ [9].

Injury-related characteristics. At the three month interview, participants were asked to report whether the injury cause was intentional (assault); whether, at the time of injury, they felt the injury was a threat to their life; and a threat of severe longer-term disability. For each of these separate variables, those responding ‘yes’ or ‘maybe/possibly’ were grouped together and compared to those responding ‘no’. Information about post-injury access to healthcare services was obtained by asking people at the three month interview if they had trouble getting to or contacting health services; ‘yes’ and ‘mixed’ were grouped together and compared to those who said ‘no’.

Twelve injury type (injury region/nature) variables, based on the International Classification of Diseases (ICD-10) injury mortality diagnosis matrix and the Barell injury diagnosis matrix, were developed using ACC data to describe the injured body region and nature of the injury [9,33,34]. All participants were classified ‘yes’ or ‘no’ for each variable according to whether or not they had sustained that injury type [35]. New Injury Severity Scores (NISS) were also derived for each participant and grouped into three categories: 1–3 (least severe), 4–6 and ≥6 (most severe) [9,36].

Analysis

Chi-squared tests were used to compare proportions hospitalised and non-hospitalised according to each explanatory variable. Proportions with a WHODAS score≥10 24 months after injury are presented with 95% confidence intervals (95%CI). To identify possible predictors of disability 24 months after injury we used Poisson models with robust standard errors [37]. Using these models we can directly estimate the relative risks for binary outcomes. A two-part process was used for model-building. Firstly, independent models were built for each of the hospitalised and non-hospitalised sub-groups using a stepwise backward selection procedure with a p-value threshold of ≤0.10. All participants and all explanatory variables listed in Tables 1, 2, 3 were eligible for inclusion in this step; certain key variables (pre-injury WHODAS, age, sex, NISS, ethnicity, 12 injury types) were retained in all models; time between date of injury and 24 month interview was adjusted for in all models [9]. Prior knowledge and use of results from previous analyses informed identification of variables to be considered or retained, irrespective of p-values, to mitigate drawbacks associated with automated stepwise techniques available in statistical software. In our earlier paper, examining disability three months after injury [9], a separate ‘undisclosed’ category was created for three variables with high item-missingness (BMI, comfort in faith or spiritual beliefs and sense of community) to allow participants’ missing responses for these variables to be included in model-building. These ‘undisclosed’ categories were maintained in this analysis too.

All variables retained in either of the independent models for the hospitalised and non-hospitalised groups were then consistently retained in two further models, allowing us to present relative risks consistently for both groups. This was done to allow readers to ascertain whether or not a variable which is (say) marginally non-significant in the hospitalised group, may have an effect in the same direction as a significant finding in the non-hospitalised group. The final multivariable models (complete case analyses) include all participants with non-missing responses for the retained variables (apart from the three mentioned above with an ‘undisclosed’ category). Model fit was assessed using deviance goodness-of-fit test.

Missingness in our complete case analysis is unlikely be ‘missing completely at random’ [38], therefore results from this analysis may be biased. We undertook sensitivity analyses using inverse probability weighting to investigate this [39]. The main reason for participants not being included in the complete case analysis was not facing the 24 month interview. Our previous analyses identified males, young adults, Māori, participants living with non-family members, and those with inadequate household income as more likely to not participate in the 24 month interview [40]. Further to this, in our present study, by comparing participants with complete data with those with incomplete data, we identified missingness as being related to BMI, smoking, and depressive-type episode status. Therefore, we used each of the above variables as predictors in a logistic regression to estimate the probability of each participant being in the complete case analysis, and then re-analysed the complete cases using weights equal to the inverse of that probability. Results from this analysis were compared with those from the complete case analysis to investigate the sensitivity of our results to missingness (see Discussion).

Stata 12.1 was used for analyses [41].
Results

Of 2856 participants in the three month interview, 2256 (79%) participated in the 24 month interview. As some were missing pre-injury or 24 month WHODAS disability outcome scores, the analyses are restricted to the 2184 (76%) participants for whom both pre-injury and 24 month follow-up WHODAS data were available. Of these, 548 (25%) were hospitalised within seven days of the injury event; the remainder were classified as non-hospitalised (n = 1636).

Univariate Analyses

Tables 1, 2, 3 present pre-injury socio-demographic, pre-injury health and psychosocial, and injury-related characteristics according to whether or not participants had been hospitalised. Among pre-injury socio-demographic characteristics, a greater proportion of males were hospitalised (Table 1). Apart from pre-injury optimism which was reported more among those hospitalised, no statistically significant differences between the hospitalised and non-hospitalised groups were observed in proportions reporting pre-injury health and psychosocial characteristics, including pre-injury disability (WHODAS ≥ 10) (Table 2). Differences are apparent between the groups for many of the injury-related characteristics (Table 3). Intentional injury cause (assault) was more prevalent among the hospitalised, as was a perceived threat to their life at the time of injury, a threat of longer-term disability and injury severity scores of NISS ≥ 4. Seven injury type variables were more prevalent among the hospitalised group, and two (spine and lower extremity sprain/strain or dislocation) more prevalent among the non-hospitalised.

Similar proportions in both the hospitalised and non-hospitalised groups, were experiencing disability (WHODAS ≥ 10) at 24 months (13.1%; 95% CI = 11.4%, 14.7% and 13.0%; 95% CI = 10.4%, 16.3% respectively). There were no substantial differences in 24 month disability according to age or sex for either the hospitalised or non-hospitalised groups (Table 4). For other pre-injury socio-demographic variables such as education, working for pay and household income, differences in proportions experiencing disability are apparent among both the hospitalised and non-hospitalised groups, although 95%CI are not always distinct. For Māori, and considering the hospitalised and non-hospitalised groups together, the overall proportion experiencing disability 24 months after injury is 19%; and 15% for Pacific participants. The proportion of Māori experiencing disability was significantly higher than non-Māori for those hospitalised. Participants with pre-injury disability were more likely to have disability 24 months after injury than those with no/lesser pre-injury disability for both the hospitalised and non-hospitalised groups (Table 5). Among other pre-injury health and psychosocial variables, differences in proportions experiencing disability at 24 months can also be observed, but in most instances the 95%CI are not distinct. An exception is general health, among both the hospitalised and non-hospitalised groups, where a higher proportion of those with fair/poor health pre-injury experience disability 24 months after injury.
A greater proportion of those with two or more pre-injury chronic conditions also experience disability 24 months after injury for both the hospitalised and non-hospitalised groups, as do those with a pre-injury depressive-type episode and those who reported smoking pre-injury. A greater proportion of those with BMI $\geq 30$ experience 24 month disability among the non-hospitalised group, as do those reporting less optimism pre-injury and not satisfied with social relationships pre-injury. A greater proportion of the hospitalised group experience 24 month disability if they reported poor self-efficacy or fewer nights with at least seven hours sleep pre-injury. Among the injury-related variables and considering the hospitalised group, higher proportions of those perceiving a threat to their life or a threat of disability experience disability at 24 months (Table 6). For the non-hospitalised group, higher

**Table 2.** Pre-injury health and psychosocial characteristics of 24-month interview participants according to hospitalisation status (N = 2184).

| Characteristics                      | Hospitalised | Non-hospitalised | P value** |
|--------------------------------------|--------------|------------------|-----------|
|                                      | n = 548     | %*              | n = 1636  | %*          |
| Pre-injury WHODAS score              |              |                 |           |             |
| 0 to 9                               | 521          | 95.1            | 1548      | 94.6        | 0.68       |
| $\geq$10                             | 27           | 4.9             | 88        | 5.4         |            |
| General health                       |              |                 |           |             |
| Excellent/Very good/Good             | 524          | 95.8            | 1540      | 94.4        | 0.21       |
| Fair/Poor                            | 23           | 4.2             | 91        | 5.6         |            |
| Chronic conditions                   |              |                 |           |             |
| 0                                    | 285          | 53.4            | 805       | 50.9        | 0.39       |
| 1                                    | 148          | 27.7            | 435       | 27.5        |            |
| $\geq$2                               | 101          | 18.9            | 342       | 21.6        |            |
| Depressive-type episode               |              |                 |           |             |
| No                                   | 446          | 81.4            | 1317      | 80.8        | 0.74       |
| Yes                                  | 102          | 18.6            | 314       | 19.3        |            |
| Optimism                             |              |                 |           |             |
| Yes                                  | 496          | 91.3            | 1411      | 87.6        | 0.02       |
| No                                   | 47           | 8.7             | 200       | 12.4        |            |
| Self-efficacy                        |              |                 |           |             |
| Not poor                             | 506          | 93.0            | 1468      | 90.7        | 0.09       |
| Poor                                 | 38           | 7.0             | 151       | 9.3         |            |
| Comfort in faith or spiritual beliefs |              |                 |           |             |
| Very much/Quite a bit                | 171          | 31.2            | 555       | 33.9        | 0.28       |
| Some/A little bit/None               | 359          | 65.5            | 1013      | 61.9        |            |
| Undisclosed                          | 18           | 3.3             | 68        | 4.2         |            |
| Family involvement                   |              |                 |           |             |
| Very large/Large                     | 482          | 88.3            | 1468      | 90.3        | 0.17       |
| Small/Very small                     | 64           | 11.7            | 157       | 9.7         |            |
| Social relationships                 |              |                 |           |             |
| Satisfied                            | 513          | 94.1            | 1534      | 94.2        | 0.93       |
| Not satisfied                        | 32           | 5.9             | 94        | 5.8         |            |
| Sense of community                   |              |                 |           |             |
| Strong                               | 149          | 27.2            | 493       | 30.1        | 0.63       |
| In-between                           | 237          | 43.3            | 683       | 41.8        |            |
| Little                               | 136          | 24.8            | 385       | 23.5        |            |
| Undisclosed                          | 26           | 4.7             | 75        | 4.6         |            |
| Physical activity                    |              |                 |           |             |
| $\geq$5 days                         | 300          | 56.0            | 863       | 53.7        | 0.37       |
| $<$5 days                            | 236          | 44.0            | 743       | 46.3        |            |
| Sleep                                |              |                 |           |             |
| $\geq$5 nights                       | 416          | 77.5            | 1221      | 75.8        | 0.43       |
| $<$5 nights                          | 121          | 22.5            | 390       | 24.2        |            |
| BMI                                  |              |                 |           |             |
| $<30$                                | 401          | 73.2            | 1180      | 72.1        | 0.37       |
| $\geq30$                             | 123          | 22.5            | 401       | 24.5        |            |
| Undisclosed                          | 24           | 4.4             | 55        | 3.4         |            |
| Smoking                              |              |                 |           |             |
| No                                   | 405          | 74.2            | 1196      | 73.2        | 0.65       |
| Yes                                  | 141          | 25.8            | 438       | 26.8        |            |
| Alcohol use                          |              |                 |           |             |
| Low                                  | 255          | 47.0            | 813       | 50.0        | 0.29       |
| Moderate                             | 183          | 33.7            | 543       | 33.4        |            |
| High                                 | 105          | 19.3            | 271       | 16.7        |            |
| Recreational drug use                |              |                 |           |             |
| No                                   | 444          | 81.3            | 1364      | 83.5        | 0.25       |
| Yes                                  | 102          | 18.7            | 270       | 16.5        |            |

*Column percentage. Missing cases excluded from numerator and denominator unless labelled as Undisclosed.**

**P value from Chi-squared test to compare hospitalised and non-hospitalised groups for each factor considered.
doi:10.1371/journal.pone.0080194.t002
proportions of those experiencing intentional injury cause (assault), experiencing post-injury trouble accessing healthcare services, sustaining an intracranial injury or spine sprain/dislocation, experience disability at 24 months; whereas smaller proportions with an upper extremity fracture experience disability.

**Multivariable Analyses**

Table 7 presents the final multivariable models providing relative risks of disability 24 months after injury for both the hospitalised and non-hospitalised groups. In addition to the ‘undisclosed’ category created for three variables (BMI, comfort in faith or spiritual beliefs and sense of community), some participants were missing responses to one or more of the other variables in the final multivariable models. Data were available for 1964 (90%) of the 2184 participants in this analysis; 25% (n = 501) of these were hospitalised and 75% (n = 1463) non-hospitalised. Model fit was acceptable for both models (p = 0.98 and 0.94 for non-hospitalised and hospitalised respectively).

### Table 3. Injury-related characteristics of 24-month interview participants according to hospitalisation status (N = 2184).

| Characteristics                        | Hospitalised | Non-hospitalised | P value** |
|----------------------------------------|--------------|------------------|-----------|
|                                        | n = 548 | %* | n = 1636 | %* |             |
| **Injury cause**                       |           |                 |           |                 |             |
| Unintentional                          | 514      | 94.1            | 1585      | 97.2            | <0.001     |
| Intentional (assault)                  | 32       | 5.9             | 45        | 2.8             |             |
| **Threat to life**                     |           |                 |           |                 |             |
| No                                     | 407      | 76.7            | 1498      | 92.4            | <0.001     |
| Yes/Maybe                              | 124      | 23.4            | 123       | 7.6             |             |
| **Threat of severe long-term disability** |           |                 |           |                 |             |
| No                                     | 257      | 48.3            | 1018      | 63.1            | <0.001     |
| Yes/Maybe                              | 275      | 51.7            | 596       | 36.9            |             |
| **Access to healthcare services**      |           |                 |           |                 |             |
| No trouble                             | 477      | 88.0            | 1471      | 90.9            | 0.05       |
| Trouble/mixed                          | 65       | 12.0            | 148       | 9.1             |             |
| **Injury severity**                    |           |                 |           |                 |             |
| NISS 1–3                               | 133      | 24.9            | 724       | 45.9            | <0.001     |
| NISS 4–6                               | 272      | 50.8            | 675       | 42.8            |             |
| NISS >6                                 | 130      | 24.3            | 177       | 11.2            |             |
| **Injury types**                       |           |                 |           |                 |             |
| Intracranial injury                    |           |                 |           |                 |             |
| No                                     | 504      | 92.0            | 1595      | 97.5            | <0.001     |
| Yes                                    | 44       | 8.0             | 41        | 2.5             |             |
| Head/neck superficial injury           |           |                 |           |                 |             |
| No                                     | 506      | 92.3            | 1596      | 97.6            | <0.001     |
| Yes                                    | 42       | 7.7             | 40        | 2.4             |             |
| Spine sprain or dislocation            |           |                 |           |                 |             |
| No                                     | 509      | 92.9            | 1328      | 81.2            | <0.001     |
| Yes                                    | 39       | 7.1             | 308       | 18.8            |             |
| Upper extremity fracture               |           |                 |           |                 |             |
| No                                     | 398      | 72.6            | 1393      | 85.2            | <0.001     |
| Yes                                    | 150      | 27.4            | 243       | 14.9            |             |
| Upper extremity sprain or dislocation  |           |                 |           |                 |             |
| No                                     | 485      | 88.5            | 1393      | 85.2            | 0.05       |
| Yes                                    | 63       | 11.5            | 243       | 14.9            |             |
| Upper extremity open wound             |           |                 |           |                 |             |
| No                                     | 495      | 90.3            | 1579      | 96.5            | <0.001     |
| Yes                                    | 53       | 9.7             | 57        | 3.5             |             |
| Upper extremity superficial injury     |           |                 |           |                 |             |
| No                                     | 524      | 95.6            | 1559      | 95.3            | 0.75       |
| Yes                                    | 24       | 4.4             | 77        | 4.7             |             |
| Lower extremity fracture               |           |                 |           |                 |             |
| No                                     | 387      | 70.6            | 1419      | 86.7            | <0.001     |
| Yes                                    | 161      | 29.4            | 217       | 13.3            |             |
| Lower extremity sprain or dislocation  |           |                 |           |                 |             |
| No                                     | 475      | 86.7            | 1151      | 70.4            | <0.001     |
| Yes                                    | 73       | 13.3            | 485       | 29.7            |             |
| Lower extremity open wound             |           |                 |           |                 |             |
| No                                     | 508      | 92.7            | 1592      | 97.3            | <0.001     |
| Yes                                    | 40       | 7.3             | 44        | 2.7             |             |
| Lower extremity superficial injury     |           |                 |           |                 |             |
| No                                     | 515      | 94.0            | 1522      | 93.0            | 0.44       |
| Yes                                    | 33       | 6.0             | 114       | 7.0             |             |
| Other injury                           |           |                 |           |                 |             |
| No                                     | 377      | 68.8            | 1415      | 86.5            | <0.001     |
| Yes                                    | 171      | 31.2            | 221       | 13.5            |             |

*Column percentage. Missing cases excluded from numerator and denominator.

**P value from Chi-squared test to compare hospitalised and non-hospitalised groups for each factor considered.

#Multiple injury types possible.

doi:10.1371/journal.pone.0080194.t003

Multivariable Analyses

Table 7 presents the final multivariable models providing relative risks of disability 24 months after injury for both the hospitalised and non-hospitalised groups. In addition to the 'undisclosed' category created for three variables (BMI, comfort in faith or spiritual beliefs and sense of community), some participants were missing responses to one or more of the other variables in the final multivariable models. Data were available for 1964 (90%) of the 2184 participants in this analysis; 25% (n = 501) of these were hospitalised and 75% (n = 1463) non-hospitalised. Model fit was acceptable for both models (p = 0.98 and 0.94 for non-hospitalised and hospitalised respectively).

**Pre-injury socio-demographic characteristics.** Māori in the hospitalised group were at 70% increased risk of disability...
compared to non-Māori, whilst taking account of a range of pre-injury and injury-related variables in the modelling, although the 95%CI included 1 (95%CI = 1.0,2.9; p = 0.06). There was weak evidence (p = 0.02) to suggest risk of disability differed by age for those in the non-hospitalised group. There was no evidence to suggest that risk of disability differed for those within the separate categories of sex, Pacific ethnicity or living arrangements. Highest educational qualifications, working for pay and household income were not retained in the final models.

Pre-injury health and psychosocial characteristics. Having a pre-injury WHODAS≥10 increased the risk of post-injury disability (24 months after injury) for both the hospitalised (RR = 2.4; 95%CI = 1.3,4.5; p = 0.006) and non-hospitalised (RR = 2.6; 95%CI = 1.8,3.7; p<0.001) groups. Having two or more chronic conditions pre-injury, compared to having none, also independently predicted an increased risk of disability 24 months after injury among the hospitalised (RR = 3.0; 95%CI = 1.6,5.3; p = 0.001); and non-hospitalised (RR = 1.4; 95%CI = 1.0,2.0; p = 0.04) groups. Not being optimistic pre-injury increased the risk of disability among the hospitalised group (RR = 1.9; 95%CI = 1.0,3.4; p = 0.04); whereas having a depressive-type episode pre-injury increased the risk of disability among the non-hospitalised group (RR = 1.4; 95%CI = 1.0,1.9; p = 0.03). Having a BMI≥30 independently predicted an increased risk of disability compared to those with BMI<30 in both the hospitalised and non-hospitalised groups (RR = 1.9; 95%CI = 1.1,3.2; p = 0.02 and RR = 1.4; 95%CI = 1.1,1.9; p = 0.02, respectively). There was weak evidence that cigarette smoking was associated with an increased risk of disability among the hospitalised and non-hospitalised groups (RR = 1.6; 95%CI = 1.0,2.5; p = 0.07 and RR = 1.3; 95%CI = 1.0,1.7; p = 0.06, respectively). There was no evidence to suggest a relationship existed between sense of community and risk of disability. General health, self-efficacy, comfort in faith or spiritual beliefs, family involvement, social relationships, physical activity, sleep, and alcohol and recreational drug use were not retained in the final models.

Injury-related characteristics. Intentional injury cause (assault) increased the risk of disability among the non-hospitalised group only (RR = 2.5;95%CI = 1.4,4.5; p = 0.002). Perceived threat of longer-term disability at the time of injury increased the risk of disability among the hospitalised group only (RR = 2.8;95%CI = 1.6,5.0;p<0.001). Having trouble accessing healthcare services independently predicted an increased risk of disability for both the hospitalised and non-hospitalised groups (RR = 1.9;95%CI = 1.1,3.4;p = 0.03; RR = 1.7; 95%CI = 1.2,2.5; p = 0.003, respectively). Perceived threat to life at the time of the injury event was not retained in the final models.

There was no evidence to suggest a relationship existed between anatomical severity of injury and risk of disability for either the hospitalised or non-hospitalised group. For the hospitalised group head/neck superficial injury predicted risk of disability (RR = 2.3;95%CI = 1.2,4.4; p = 0.01); whereas intracranial injury

### Table 4. Prevalence of participants with disability (WHODAS≥10) 24 months after injury according to pre-injury socio-demographic characteristics and hospitalisation status.

| Characteristics                                      | Hospitalised (n = 548) | Non-hospitalised (n = 1636) |
|-------------------------------------------------------|------------------------|-----------------------------|
|                                                       | % 95% CI                | % 95% CI                    |
| Age 18–24 years                                       | 5.7 1.6                 | 10.1 6.1                    |
| 25–34 years                                           | 10.8 5.7                | 10.6 7.4                    |
| 35–44 years                                           | 15.2 9.4                | 10.4 7.4                    |
| 45–54 years                                           | 11.8 6.7                | 16.9 13.5                   |
| 55–64 years                                           | 19.1 12.4               | 14.4 10.8                   |
| Sex                                                   |                        |                             |
| Male                                                  | 13.4 10.1               | 12.1 10.1                   |
| Female                                                | 12.6 8.3                | 14.0 11.6                   |
| Māori ethnicity                                       |                        |                             |
| No                                                    | 10.2 7.5                | 12.4 10.7                   |
| Yes                                                   | 25.7 17.7               | 16.0 11.8                   |
| Pacific ethnicity                                     |                        |                             |
| No                                                    | 12.9 10.1               | 12.9 11.2                   |
| Yes                                                   | 15.9 6.6                | 14.7 8.5                    |
| Highest educational qualification                     |                        |                             |
| Post-secondary school                                 | 10.6 7.5                | 13.1 11.0                   |
| Secondary school                                      | 14.4 8.9                | 9.9 7.1                     |
| No qualifications                                     | 22.8 14.1               | 18.4 13.6                   |
| Living arrangements                                   |                        |                             |
| With family                                           | 12.4 9.5                | 13.0 11.2                   |
| With non-family                                       | 9.5 2.7                 | 8.9 4.5                     |
| Alone                                                 | 21.3 11.9               | 16.0 10.5                   |
| Working for pay                                       |                        |                             |
| Yes                                                   | 11.2 8.6                | 12.5 10.8                   |
| No                                                    | 32.0 19.5               | 18.8 12.2                   |
| Household income                                      |                        |                             |
| Adequate                                              | 11.8 9.1                | 12.6 10.9                   |
| Inadequate                                            | 27.5 14.6               | 17.8 12.0                   |

*Multiple ethnicities possible.*

doi:10.1371/journal.pone.0080194.t004
(RR = 2.0; 95%CI = 1.0, 4.0; p = 0.04) and spine sprain or dislocation (RR = 1.6; 95%CI = 1.1, 2.5; p = 0.01) predicted an increased risk of disability 24 months later among the non-hospitalised group. In the hospitalised group, those with a lower extremity open wound were at decreased risk of disability at 24 months compared to those with other injuries (RR = 0.15; 95%CI = 0.03, 0.88; p = 0.04). There was insufficient evidence for the remaining injury types independently predicting risk of disability.

### Table 5. Prevalence of participants with disability (WHODAS≥10) 24 months after injury according to pre-injury health and psychosocial characteristics and hospitalisation status.

| Characteristics                        | Prevalence (95%CI) of WHODAS≥10 at 24-months |
|----------------------------------------|-----------------------------------------------|
|                                        | Hospitalised (n = 548)                      | Non-hospitalised (n = 1636)                  |
|                                        | % 95% CI                                     | % 95% CI                                     |
| Pre-injury WHODAS score                 |                                               |                                               |
| 0 to 9                                 | 10.7 8.2 13.7                               | 11.3 9.8 13.0                                |
| ≥10                                    | 59.3 38.8 77.6                               | 42.0 31.6 53.0                               |
| General health                         |                                               |                                               |
| Excellent/Very good/Good               | 12.0 9.4 15.1                               | 11.8 10.2 13.5                               |
| Fair/Poor                              | 39.1 19.7 61.5                               | 34.1 24.5 44.7                               |
| Chronic conditions                     |                                               |                                               |
| 0                                      | 7.7 4.9 11.5                                | 9.8 7.8 12.1                                 |
| 1                                      | 10.1 5.8 16.2                               | 11.5 8.7 14.9                                |
| ≥2                                     | 32.7 23.7 42.7                               | 22.8 18.5 27.6                               |
| Depressive-type episode                 |                                               |                                               |
| No                                     | 11.4 8.6 14.8                               | 10.9 9.3 12.7                                |
| Yes                                    | 20.6 13.2 29.7                               | 21.7 17.2 26.6                               |
| Optimism                               |                                               |                                               |
| Yes                                    | 12.3 9.5 15.5                               | 12.3 10.6 14.1                               |
| No                                     | 23.4 12.3 38.0                               | 19.5 14.2 25.7                               |
| Self-efficacy                          |                                               |                                               |
| Not poor                               | 12.1 9.3 15.2                               | 12.5 10.9 14.3                               |
| Poor                                   | 28.9 15.4 45.9                               | 18.5 12.7 25.7                               |
| Comfort in faith or spiritual beliefs  |                                               |                                               |
| Very much/Quite a bit                  | 15.2 10.2 21.5                               | 14.8 11.9 18.0                               |
| Some/A little bit/None                  | 12.5 9.3 16.4                               | 12.0 10.1 14.2                               |
| Undisclosed                            | 5.6 0.1 27.3                                | 11.8 5.2 21.8                                |
| Family involvement                     |                                               |                                               |
| Very large/Large                       | 12.4 9.6 15.7                               | 12.7 11.0 14.5                               |
| Small/Very small                       | 18.8 10.1 30.5                               | 15.3 10.0 21.9                               |
| Social relationships pre-injury        |                                               |                                               |
| Satisfied                              | 12.9 10.1 16.1                               | 12.3 10.7 14.1                               |
| Not satisfied                          | 18.8 7.2 36.4                               | 23.4 15.3 33.3                               |
| Sense of community                     |                                               |                                               |
| Strong                                 | 15.4 10.0 22.3                               | 12.2 9.4 15.4                               |
| In-between                             | 11.8 8.0 16.6                               | 11.1 8.9 13.7                               |
| Little                                 | 12.5 7.5 19.3                               | 15.8 12.3 19.9                               |
| Undisclosed                            | 15.4 4.4 34.9                               | 20.0 11.6 30.8                               |
| Physical activity                      |                                               |                                               |
| ≥5 days                                | 13.7 10.0 18.1                               | 12.4 10.3 14.8                               |
| <5 days                                | 12.3 8.4 17.2                               | 13.7 11.3 16.4                               |
| Sleep                                  |                                               |                                               |
| ≥5 nights                              | 10.6 7.8 13.9                               | 12.7 10.9 14.7                               |
| <5 nights                              | 22.3 15.2 30.8                               | 13.8 10.6 17.7                               |
| BMI                                     |                                               |                                               |
| <30                                    | 10.7 7.9 14.2                               | 11.3 9.5 13.2                               |
| ≥30                                    | 19.5 12.9 27.6                               | 16.7 13.2 20.7                               |
| Undisclosed                            | 20.8 7.1 42.2                               | 21.8 11.8 35.0                               |
| Smoking                                |                                               |                                               |
| No                                     | 10.9 8.0 14.3                               | 11.5 9.8 13.5                               |
| Yes                                    | 19.9 13.6 27.4                               | 16.9 13.5 20.7                               |
| Alcohol use                            |                                               |                                               |
| Low                                    | 12.9 9.1 17.7                               | 14.8 12.4 17.4                               |
| Moderate                               | 12.6 8.1 18.3                               | 10.7 8.2 13.6                               |
| High                                   | 15.2 9.0 23.6                               | 11.8 8.2 16.3                               |
| Recreational drug use                  |                                               |                                               |
| No                                     | 11.9 9.1 15.3                               | 13.3 11.5 15.2                               |
| Yes                                    | 18.6 11.6 27.6                               | 11.5 7.9 15.9                               |

doi:10.1371/journal.pone.0080194.t005
Discussion

Our focus was on comparing hospitalised and non-hospitalised groups within a cohort comprising participants with a range of injury types, across a wide range of possible pre-injury and injury-related predictors of disability 24 months after injury (Tables 1, 2, 3, 4, 5, 6). Previously, we have reported that, three months after injury, the prevalence of disability was 54% for the hospitalised group and 39% for the non-hospitalised group [9]. By 24 months after injury, the prevalence of disability is considerably lower, at 13% for both. It is important to note that, while the proportion disabled has reduced over time, the reported pre-injury prevalence of disability (5%) has not been reached 24 months after injury [9]. Univariate analyses indicate that, of those hospitalised following injury, a greater proportion of Māori experience disability at 24 months than non-Māori (26% Māori compared to 10% non-

| Characteristics                           | Prevalence (95%CI) of WHODAS≥10 at 24-months |
|------------------------------------------|---------------------------------------------|
|                                          | Hospitalised (n = 548)                      | Non-hospitalised (n = 1636)                  |
|                                          | %   | 95% CI | %   | 95% CI |
| Injury cause                             |      |        |      |        |
| Unintentional                            | 12.8 | 10.1  | 16.0 | 12.5  | 10.9  |
| Intentional (assault)                    | 18.8 | 7.2   | 36.4 | 31.1  | 18.2  |
| Threat to life                           |      |        |      |        |
| No                                       | 10.8 | 8.0   | 14.2 | 12.6  | 10.9  |
| Yes/Maybe                                | 20.2 | 13.5  | 28.3 | 18.7  | 12.2  |
| Threat of severe long-term disability    |      |        |      |        |
| No                                       | 6.6  | 3.9   | 10.4 | 12.5  | 10.5  |
| Yes/Maybe                                | 19.3 | 14.8  | 24.4 | 13.9  | 11.2  |
| Access to healthcare services            |      |        |      |        |
| No trouble                               | 11.9 | 9.2   | 15.2 | 12.2  | 10.5  |
| Trouble/Mixed                            | 20.0 | 11.1  | 31.8 | 20.9  | 14.7  |
| Injury severity                          |      |        |      |        |
| NISS 1–3                                 | 15.0 | 9.4   | 22.3 | 14.4  | 11.9  |
| NISS 4–6                                 | 9.6  | 6.3   | 13.7 | 11.0  | 8.7   |
| NISS >6                                   | 19.2 | 12.8  | 27.1 | 14.7  | 9.8   |
| Injury types #                           |      |        |      |        |
| Intracranial injury                      |      |        |      |        |
| No                                       | 12.5 | 9.7   | 15.7 | 12.5  | 11.0  |
| Yes                                      | 20.5 | 9.8   | 35.3 | 29.3  | 16.1  |
| Head/neck superficial injury             |      |        |      |        |
| No                                       | 12.8 | 10.1  | 16.1 | 12.7  | 11.1  |
| Yes                                      | 16.7 | 7.0   | 31.3 | 25.0  | 12.7  |
| Spine sprain or dislocation              |      |        |      |        |
| No                                       | 10.4 | 7.9   | 13.4 | 11.4  | 9.8   |
| Yes                                      | 23.1 | 11.1  | 39.3 | 19.5  | 15.2  |
| Upper extremity fracture                 |      |        |      |        |
| No                                       | 14.3 | 11.0  | 18.2 | 13.9  | 12.1  |
| Yes                                      | 10.0 | 5.7   | 16.0 | 7.8   | 4.8   |
| Upper extremity sprain or dislocation    |      |        |      |        |
| No                                       | 13.2 | 10.3  | 16.5 | 12.3  | 10.6  |
| Yes                                      | 12.7 | 5.6   | 23.5 | 16.9  | 12.4  |
| Upper extremity open wound               |      |        |      |        |
| No                                       | 13.9 | 11.0  | 17.3 | 12.8  | 11.2  |
| Yes                                      | 5.7  | 1.2   | 5.7  | 1.2   | 29.9  |
| Upper extremity superficial injury       |      |        |      |        |
| No                                       | 12.8 | 10.0  | 16.0 | 12.7  | 11.1  |
| Yes                                      | 20.8 | 7.1   | 42.2 | 18.2  | 10.3  |
| Lower extremity fracture                 |      |        |      |        |
| No                                       | 12.4 | 9.3   | 16.1 | 13.6  | 11.9  |
| Yes                                      | 14.9 | 9.8   | 21.4 | 8.8   | 5.4   |
| Lower extremity sprain or dislocation    |      |        |      |        |
| No                                       | 12.4 | 9.6   | 15.7 | 13.8  | 11.9  |
| Yes                                      | 17.8 | 9.8   | 28.5 | 10.9  | 8.3   |
| Lower extremity open wound               |      |        |      |        |
| No                                       | 14.0 | 11.1  | 17.3 | 13.1  | 11.5  |
| Yes                                      | 2.5  | 0.1   | 13.2 | 6.8   | 1.4   |
| Lower extremity superficial injury       |      |        |      |        |
| No                                       | 13.2 | 10.4  | 16.4 | 13.2  | 11.5  |
| Yes                                      | 12.1 | 3.4   | 28.2 | 9.6   | 4.9   |
| Other injury                             |      |        |      |        |
| No                                       | 11.1 | 8.1   | 14.8 | 12.6  | 10.9  |
| Yes                                      | 17.5 | 12.2  | 24.1 | 15.4  | 10.9  | 20.8  |

#Multiple injury types possible.

doi:10.1371/journal.pone.0080194.t006
Table 7. Multivariable analyses of pre-injury and injury-related characteristics associated with disability (WHODAS $\geq 10$) 24 months after injury for hospitalised and non-hospitalised groups.

| Characteristics                      | Hospitalised (n = 501) | Non-hospitalised (n = 1463) |
|--------------------------------------|-----------------------|-----------------------------|
|                                      | RR*  95% CI    | RR  95% CI               |
| **Pre-injury socio-demographic**      |                       |                            |
| Age 18–24 years Ref                   |                       |                            |
| 25–34 years                          | 2.18 (0.50 9.51)      | 0.78 (0.46 1.31)           |
| 35–44 years                          | 3.96 (0.91 17.20)     | 0.78 (0.46 1.32)           |
| 45–54 years                          | 2.94 (0.64 13.47)     | 1.35 (0.83 2.20)           |
| 55–64 years                          | 2.72 (0.57 13.04)     | 1.12 (0.67 1.89)           |
| Sex Male Ref                         |                       |                            |
| Female                               | 0.98 (0.57 1.72)      | 1.03 (0.79 1.34)           |
| Māori ethnicity No Ref               | 1.69 (0.98 2.93)      | 1.04 (0.76 1.44)           |
| Yes                                  | 1.20 (0.53 2.75)      | 1.18 (0.70 1.99)           |
| Pacific ethnicity No Ref             |                       |                            |
| Yes                                  | 1.52 (0.85 2.74)      | 0.93 (0.66 1.30)           |
| ≥2                                   | 3.02 (1.57 5.78)      | 1.42 (1.02 1.98)           |
| Optimism No Ref                      | 1.87 (1.02 3.43)      | 1.15 (0.82 1.63)           |
| Yes                                  | 0.72 (0.40 1.29)      | 1.39 (1.04 1.88)           |
| Sense of community Strong Ref        |                       |                            |
| In-between                           | 0.99 (0.60 1.64)      | 0.88 (0.64 1.21)           |
| Little                               | 0.79 (0.44 1.41)      | 1.25 (0.90 1.73)           |
| Undisclosed                           | 1.44 (0.51 4.06)      | 1.38 (0.76 2.51)           |
| BMI <30 Ref                          | 1.88 (1.11 3.20)      | 1.43 (1.07 1.91)           |
| ≥30                                  | 2.54 (0.89 7.26)      | 1.73 (0.90 3.30)           |
| Smoking No Ref                       | 1.56 (0.97 2.52)      | 1.31 (0.99 1.73)           |
| Yes                                  | 0.72 (0.40 1.29)      | 1.39 (1.04 1.88)           |
| Pre-injury health and psychosocial   |                       |                            |
| Pre-injury WHODAS score 0–9 Ref      |                       |                            |
| ≥10                                  | 2.41 (1.28 4.53)      | 2.57 (1.81 3.66)           |
| Chronic conditions 0 Ref             |                       |                            |
| 1                                    | 1.52 (0.85 2.74)      | 0.93 (0.66 1.30)           |
| ≥2                                   | 3.02 (1.57 5.78)      | 1.42 (1.02 1.98)           |
| Optimism No Ref                      | 1.87 (1.02 3.43)      | 1.15 (0.82 1.63)           |
| Yes                                  | 0.72 (0.40 1.29)      | 1.39 (1.04 1.88)           |
| Sense of community Strong Ref        |                       |                            |
| In-between                           | 0.99 (0.60 1.64)      | 0.88 (0.64 1.21)           |
| Little                               | 0.79 (0.44 1.41)      | 1.25 (0.90 1.73)           |
| Undisclosed                           | 1.44 (0.51 4.06)      | 1.38 (0.76 2.51)           |
| BMI <30 Ref                          | 1.88 (1.11 3.20)      | 1.43 (1.07 1.91)           |
| ≥30                                  | 2.54 (0.89 7.26)      | 1.73 (0.90 3.30)           |
| Smoking No Ref                       | 1.56 (0.97 2.52)      | 1.31 (0.99 1.73)           |
| Injury-related                       |                       |                            |
| Injury cause Unintentional Ref       |                       |                            |
| Intentional (assault)                | 0.87 (0.36 2.12)      | 2.49 (1.38 4.49)           |
| Threat of severe long-term disability|                       |                            |
| No Ref                               | 1.92 (1.08 3.40)      | 1.73 (1.20 2.50)           |
| Yes/ Maybe                           | 2.84 (1.61 4.99)      | 0.86 (0.66 1.14)           |
| Access to healthcare services No trouble Ref |       |                            |
| Trouble/Mixed                        | 1.92 (1.08 3.40)      | 1.73 (1.20 2.50)           |
| Injury severity NISS 1–3 Ref          |                       |                            |
| NISS 4–6 Ref                         | 0.51 (0.24 1.06)      | 1.11 (0.77 1.61)           |
| NISS >6 Ref                          | 0.84 (0.37 1.90)      | 1.23 (0.79 1.93)           |
| Injury types Intracranial No Ref     |                       |                            |
Maori; p<0.001) (Table 4). Disability 24 months post-injury was also more prevalent among Maori than non-Maori for the non-hospitalised group, and among Pacific than non-Pacific peoples for both the hospitalised and non-hospitalised groups, but none of these differences were statistically significant.

Multivariable analyses indicate that pre-injury disability exposes injured participants to increased risk of disability 24 months later, regardless of whether or not they were hospitalised. Data from a large survey in the United States found that people with pre-existing disability face barriers to access to services [42]. However, in our study all participants had to have contact with at least one health provider to become registered with the no-fault compensation insurer (ACC); perhaps disparities in access occur post-registration. Maori who were hospitalised have 70% increased risk of disability 24 months after injury relative to hospitalised non-Maori. This result is of borderline statistical significance however, as with all other multivariable results, is found after controlling for differences in levels of pre-injury disability and other explanatory factors. ACC has previously identified that Maori are not gaining equitable access to ACC services [43]. As stated, all POIS participants had to have gained access to at least some ACC services to be recruited to POIS, and the multivariable model also included post-injury trouble accessing health care services. Disparities in access to certain treatments have been identified for Maori with other health conditions, even when they have gained access to the healthcare system [44]. Despite healthcare services increasingly recognising and incorporating Maori needs and values, perhaps there is still more work to be done in this area [45]. If our results are confirmed by others, they suggest that more attention needs to be focused on the post-injury treatment and rehabilitation processes for Maori to redress what appears to be a considerable disparity in outcome.

The analytic approach in this paper differs somewhat from the earlier three month analyses [9]. For example, here we estimate relative risks of disability outcome rather than the odds of disability and, although the range of possible explanatory factors is held constant between the earlier investigation and this one, Maori and Pacific ethnicities were added as specific variables here; factors retained in the final models also differ between the three month and 24 month analyses. Nevertheless, as in the 24 month analyses reported here, our three month paper revealed that few explanatory factors were consistently associated with an increased risk of disability across both the hospitalised and non-hospitalised groups; in fact only pre-injury disability, BMI \( \geq 30 \) and higher anatomical injury severity (NISS) were consistently associated across the two groups three months after injury [9]. By 24 months after injury, pre-injury disability and BMI \( \geq 30 \) again place people at increased risk of disability in both the hospitalised and non-hospitalised groups, but NISS is not independently associated with increased risk of disability in either the hospitalised or non-hospitalised group. The mechanism underlying the risk for injured people with BMI \( \geq 30 \) remains to be understood (and replicated in

| Characteristics                                      | Hospitalised (n = 501) | Non-hospitalised (n = 1463) |
|------------------------------------------------------|------------------------|-----------------------------|
|                                                      | RR* 95% CI             | RR 95% CI                   |
| Head/neck superficial No Ref Ref                     |                        |                            |
| Head/neck superficial Yes 1.41 0.62 3.19             |                        | 2.03 1.03 4.04             |
| Spine sprain or dislocation No Ref Ref                |                        |                            |
| Spine sprain or dislocation Yes 2.29 1.18 4.45       |                        | 0.84 0.38 1.86             |
| Upper extremity fracture No Ref Ref                  |                        |                            |
| Upper extremity fracture Yes 1.06 0.48 2.34          |                        | 1.60 1.10 2.32             |
| Upper extremity sprain or dislocation No Ref Ref     |                        |                            |
| Upper extremity sprain or dislocation Yes 1.13 0.60 2.13 | 0.61 0.35 1.06          |
| Upper extremity open wound No Ref Ref                |                        |                            |
| Upper extremity open wound Yes 0.43 0.12 1.57        |                        | 1.47 0.82 2.63             |
| Upper extremity superficial injury No Ref Ref        |                        |                            |
| Upper extremity superficial injury Yes 1.34 0.54 3.33 |                        | 1.43 0.81 2.53             |
| Lower extremity fracture No Ref Ref                  |                        |                            |
| Lower extremity fracture Yes 1.35 0.72 2.54          |                        | 0.86 0.50 1.49             |
| Lower extremity sprain or dislocation No Ref Ref     |                        |                            |
| Lower extremity sprain or dislocation Yes 0.95 0.55 1.65 |                        | 0.95 0.62 1.45             |
| Lower extremity open wound No Ref Ref                |                        |                            |
| Lower extremity open wound Yes 0.15 0.03 0.88        |                        | 0.45 0.13 1.57             |
| Lower extremity superficial injury No Ref Ref        |                        |                            |
| Lower extremity superficial injury Yes 0.84 0.35 2.00 |                        | 0.65 0.37 1.14             |
| Other injury No Ref Ref                               |                        |                            |
| Other injury Yes 1.30 0.77 2.18                      |                        | 1.32 0.87 2.00             |

*RR = Relative risk.

doi:10.1371/journal.pone.0080194.t007
other studies); however, a meta-analysis has reported that obesity places people at increased risk of exit from work onto a disability pension [46]. At three months, post-injury trouble accessing healthcare services was associated with disability for the non-hospitalised group only [9]. By 24 months, trouble accessing healthcare services increased the risk of disability for both those with early hospital treatment and those without, relative to those reporting no trouble accessing healthcare services, and independently of age, sex, ethnicity, NISS and other potential explanatory factors. We cannot ascertain the precise mechanism underlying this increased risk of disability, but our findings suggest perceiving trouble accessing services may serve as a flag for the risk of longer-term disability. Likewise, at three months having two or more chronic conditions pre-injury was associated with disability for the hospitalised group only [9]. At 24 months, and again independently of pre-injury disability and the other variables in the models, those with two or more chronic conditions pre-injury had three times the risk of disability relative to those reporting no pre-injury chronic conditions in the hospitalised group and 1.4 times the risk in the non-hospitalised group.

As in our earlier paper, several factors were associated with disability outcome in one group or the other, but not in both [9]. Of 28 predictor variables included in the models, we identified seven that independently placed injured people at increased risk of disability 24 months after injury among the hospitalised group, and eight among the non-hospitalised group. As discussed above, four of these variables (pre-injury disability, having two or more pre-injury chronic conditions, pre-injury BMI \( \geq 30 \) and post-injury trouble accessing healthcare services) were common to both the hospitalised and non-hospitalised groups. Of those factors predicting risk of disability in one group only, those perceiving a threat of longer-term disability at the time of the injury event among the hospitalised group had the highest relative risk (nearly three-fold); the risk was not apparent for the non-hospitalised group. This finding suggests that asking people treated in hospital for their injury to report their perception of disability risk may well prove a useful indicator of those likely to experience disability outcomes in the longer-term. A lack of optimism pre-injury almost doubled the risk of 24 month disability among the hospitalised group only, as did head/neck superficial injury; whereas those with lower extremity open wound injuries who were hospitalised were at reduced risk of 24 month disability. Among the non-hospitalised group only, pre-injury depressive-type episode intentional cause (assault) and two of the 12 injury type variables (intracranial and spine sprain/dislocation) independently predicted increased risk of disability. Of particular note is intracranial injury among the non-hospitalised group that appears to have twice the risk of disability relative to those not having an intracranial injury.

Studies of injury outcome, including for people with a range of injury types, are being undertaken in different countries. As previously mentioned, finding studies directly comparable with ours is problematic due to the use of different outcome measures, variable follow-up rates, and different methods and recruitment strategies [3]. For example, the longitudinal UK Burden of Injury study recruited those attending emergency departments or admitted to hospital as a consequence of injury [5]. They have reported factors associated with self-reported recovery from injury and found, 12 months after injury, those aged 45–64 years, admitted to hospital and having a moderate or severe injury (approximating our NISS 4–6 and >6 categories) were at reduced risk of self-reported recovery relative to their reference groups [5]. Clearly, their study and outcome are not directly comparable to ours. Nor is the longitudinal study, undertaken in Norway, which identified low injury severity, not having a serious head injury, low levels of pre-injury depression, and being optimistic as independent predictors of return to work 12 months after injury among a cohort of injured patients aged 18–65 years recruited via a trauma centre [47]. A study from Norway, of 101 trauma patients with injury severity NISS \( \geq 16 \), has investigated post-injury factors associated with 24 month disability according to the WHODAS (36-item version) [48]. They found, as we did, that the proportions reporting WHODAS disability decreased with time, but not necessarily to the level reported in the general population (their study) or to pre-injury prevalence (our study). They found that gender was not associated with 24 month disability. Previously we reported women were more likely to experience disability three months after injury than men; others have also found being female places women at risk of poor outcomes [9,49,50]. However, as with the Norwegian study, we found women were not at increased risk of disability in the longer-term relative to men [48]. Again, more work is required to understand this finding.

**Strengths and Limitations**

Strengths of our investigation include being able to recruit both those with an injury resulting in treatment at hospital and those not receiving hospital treatment, using a measure of outcome specifically developed to measure disability (WHODAS), being able to recruit participants with ‘all-injury’ types, and having a wide range of pre-injury and injury-related factors to include in our analyses. It is also a strength of our study that we were able to interview participants independently of ACC (New Zealand’s no-fault compensation insurer), thereby reducing the likelihood of perverse incentives leading to an exaggeration of poor outcome (e.g. in some litigious insurance systems participants may feel the impact of the injury needs to be sustained until their case has reached court or otherwise been resolved). In fact, possibly the very existence of New Zealand’s no-fault insurer reduces such incentives. Regardless, our participants were all interviewed independently of the insurer, and knew that their results were confidential to the university research team.

Our limitations include asking participants to recall a number of pre-injury states three months after the injury; although subsequent analyses of our cohort suggest that recall bias is likely to be minor, at worst [51]. Another limitation is that few participants had high NISS (none with NISS>22). However, a study undertaken in Denmark reported no associations between higher injury severity and long-term health-related quality of life outcomes [52].

Our multivariable model presented in Table 7 was a complete case analysis, based on 69% of the cohort. The Inverse Probability Weighted sensitivity analyses we conducted did not substantially alter the results in Table 7 in terms of variables that are significantly associated with disability at 24 months. However, the results in Table 7 may overestimate the relative risks for pre-injury disability, intracranial injury and assault by 4% to 7%, while underestimating the relative risks for ‘NISS 4–6’, upper extremity fractures, and lower extremity sprain or dislocation by 7 to 8% among the non-hospitalised group (results not presented). For the hospitalised group, Table 7 may overestimate the relative risks for BMI \( \geq 30 \), and 2 or more chronic conditions by 5 to 7%, and the effect of ‘NISS 4–6’ by 19%, while underestimating the effect of pre-injury disability, head/neck superficial injury, and trouble accessing health services by 10 to 15%. The relative risk of disability at 24 months for Māori in the hospitalised group may also be underestimated by 5%. Lastly, another limitation concerns a possible lack of precision accompanying some of our risk predictions where, in reality, risks may exist. For example, we may
have lacked sufficient sample size to identify relationships between Pacific ethnicity and risk of disability at 24 months, or between other potential explanatory factors and disability where the numbers were small in some categories; particularly for the smaller hospitalised group.

Conclusions
This study reports relationships between a wide range of pre-injury and injury-related variables and risk of longer-term (24 month) disability. Certain pre-injury and injury-related variables independently predict longer-term disability, but only four pre-injury disability, having two or more pre-injury chronic conditions, pre-injury BMI≥30 and post-injury trouble accessing healthcare services are common to both the hospitalised and non-hospitalised groups. As our earlier paper suggested, our results indicate that it may be unwise to generalise from results about predictors of risk for hospitalised patients to injured non-hospitalised groups [9]. The proportions experiencing disability at 24 months have reduced from the proportions experiencing disability at three months; but they have not reduced to pre-injury levels. A considerable disability burden continues to be borne, equally, by both the hospitalised and non-hospitalised groups. It is of particular concern that Māori may experience a higher risk of disability than non-Māori. Further analysis is planned to examine pre-injury and injury-related predictors of longer-term disability, specifically for Māori in our study, to investigate, in further detail, drivers of this increased risk. It will also be interesting to see if our findings are replicated in other studies. If so, and depending on the results of robust trials, it is to be hoped that identifying and implementing appropriate interventions aimed at improving outcomes for groups of people at increased risk may result in reduced post-injury disability.

Acknowledgments
We are most grateful to the study participants for sharing their information with us, and to the study interviewers for their role in data collection. We thank Paul Hansen, Dylan Cross and Kim Allen for their comments on an earlier draft of this paper.

Author Contributions
Conceived and designed the experiments: SD JL EW SA RL GD. Performed the experiments: SD JL EW SA RL GD. Analyzed the data: AS SD SW JL EW SA RL GD. Wrote the paper: SD. Contributed to the writing of the manuscript: SW AS JL EW SA RL GD MM. ICMJE criteria for authorship read and met: SW AS JL EW SA RL GD MM. Agreed with manuscript results and conclusions: SD SW AS JL EW SA RL GD MM.

References
1. Murray C J L, Vos T, Lozano R, Naghavi M, Flaxman AD, et al. (2012) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet 380: 2197–2235.
2. Polinder S, Haagsma JA, Toet H, van Beeck EF (2012) Epidemiological burden of minor, major and fatal trauma in a national injury pyramid. British Journal of Surgery 99: 114–120.
3. Polinder S, Haagsma JA, Lyons RA, Gabble BJ, Ameratunga S, et al. (2011) Measuring the Population Burden of Fatal and Nonfatal Injury. Epidemiologic Reviews 34: 17–51.
4. Gabble BJ, Sutherland AM, Hart MJ, Cameron PA (2010) Population-Based Capture of Long-Term Functional and Quality of Life Outcomes After Major Trauma: The Experiences of the Victorian State Trauma Registry. Journal of Trauma 69: 532–536.
5. Kendrick D, Vinogradova Y, Coupland C, Mulvaney CA, Christie N, et al. (2013) Recovery from injury: the UK Burden of Injury Multicentre Longitudinal Study. Injury Prevention. Published Online First: 18 April 2013 doi:10.1136/injuryprevent-2012-000658.
6. Black J, Herbston G, Lyons R, Polinder S, Derrett S (2011) Recovery after Injury: An individual patient data meta-analysis of general health status using the EQ-5D. J Trauma 71: 1003–1010.
7. Mahn S, Krafft M, Kullgren A, Ylénius A, Tingvall C (2008) Risk of permanent medical impairment (RPMI) in road traffic accidents. Annals of Advances in Automotive Medicine 52: 95–100.
8. Soberg HL, Finset A, Roise O, Baute-Holter E (2012) The Trajectory of Physical and Mental Health From Injury to 5 Years After Multiple Trauma: A Prospective, Longitudinal Cohort Study. Archives of Physical Medicine and Rehabilitation 93: 765–774.
9. Derrett S, Samaranyaka A, Wilson S, Langley J, Ameratunga S, et al. (2012) Prevalence and Predictors of Sub-acute Phase Disability after Injury among Hospitalised and Non-Hospitalised Groups: A Longitudinal Cohort Study. PLoS One 7: e49069.
10. Statistics New Zealand (2007) QuickStats About Māori (Revised edition). Wellington: Statistics New Zealand.
11. Wyeth E, Hokoshibi B, Derrett S, Hall C, Langley J (2010) Rangatiratanga and O¯ ritetanga: Responses to the Treaty of Waitangi in a New Zealand Study. Ethnicity & Health 15: 503–516.
12. Ministry of Health (2010) Tatas Kahuhiwā: Māori Health Chart Book 2010 (2nd Edition). Wellington: Ministry of Health.
13. Ministry of Health (2012) Tupu Ola Moui: Pacific Health Chart Book 2012. Wellington: Ministry of Health.
14. Derrett S, Langley J, Hokoshibi B, Ameratunga S, Hansen P, et al. (2009) Prospective Outcomes of Injury Study. Injury Prevention 15: 351.
15. Derrett S, Davie G, Ameratunga S, Wyeth E, Colhoun S, et al. (2011) Prospective Outcomes of Injury Study: recruitment, and participant characteristics, health and disability status. Injury Prevention 17: 415–416.
16. Wyeth E, Derrett S, Hokoshibi B, Samaranyaka A (2013) Indigenous injury outcomes: life satisfaction among injured Māori in New Zealand three months after injury. Health and Quality of Life Outcomes 11(1): 120.
17. Accident Compensation Corporation (2010) Annual Report 2010. Wellington: Accident Compensation Corporation.
18. Ustun T, Kostanjsek N, Shetterly S, Rehan J, editors (2010) Measuring Health and Disability: Manual for WHO Disability Assessment Schedule (WHODAS 2.0). Malta: WHO Press.
19. Andrews G, Kemp A, Sunderland M, Von Korff M, Ustun T (2009) Normative data for the 12 item WHO Disability Assessment Schedule 2.0. PLoS One 4: e8343.
20. Statistics New Zealand (2006) 2006 Census of Population and Dwellings. Wellington: http://www.stats.govt.nz/census.aspx. Accessed 2013 October 15.
21. Deluabanti Cammock R, Derrett S, Davie G, Langley J, Sopasa T (2012) Injury to Pacific people in New Zealand: Pre-injury characteristics and early health outcomes – results from a cohort study. Australasian Epidemiologist 19: 17–21.
22. Ministry of Social Development (2008) Direct Measurement Of Living Standards: The New Zealand ELSI Scale - Survey of Working Age People in 2000. Wellington: Ministry of Social Development.
23. Warie J, Kosinski M, Gandek B (2000) SF-36® Health Survey: Manual and Interpretation Guide. Lincoln, RI: QualityMetric Incorporated.
24. Ministry of Health (2008) A Portrait of Health. Key Results from the 2006/07 New Zealand Health Survey. Wellington:Ministry of Health.
25. American Psychiatric Association Committee of Nomenclature and Statistics (1980) Diagnostic and statistical manual of mental disorder-3rd edition (DSM-3). Washington DC: American Psychiatric Association.
26. Schier M, Carver C, Bridges M (1994) Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the Life Orientation Test. Journal of Personality and Social Psychology 67: 1063–1078.
27. Schwarzer R, M J (1995) Generalized Self-Efficacy Scale. In: Weinman J, Johnston M, editors. Measures in health psychology: A user's portfolio Causal and control beliefs. Windsor, England: NFER-NELSON. 35–37.
28. Peterman A, Fitchett G, Brady M, Hernandez L, Cella D (2002) Measuring spiritual well-being in people with cancer: the functional assessment of chronic illness therapy - Spiritual Well-being Scale (FACIT-Sp). Annals of Behavioral Medicine 24: 49–58.
29. Portney K, Berry J (1997) Mobilizing minority communities. The American Behavioral Scientist 40: 632–644.
30. Sport and Recreation New Zealand (2004) The New Zealand Physical Activity Questionnaires. Wellington: SPARC.
31. World Health Organization (2011) BMI Classification. Geneva: World Health Organization.
32. Bradley KA, DeBenedetti AF, Volk RJ, Williams EC, Frank D, et al. (2007) AUDIT-C as a Brief Screen for Alcohol Misuse in Primary Care. Alcoholism: Clinical and Experimental Research 31: 1208–1217.
33. Fingerhut L, Warner M (2006) The ICD-10 injury mortality diagnosis matrix. Injury Prevention 12: 24–29.
34. Barell V, Aharonson-Daniel L, Fingerhut LA, Mackenzie EJ, Ziv A, et al. (2002) An introduction to the Barell body region by nature of injury diagnosis matrix. Injury Prevention 8: 91–96.
35. Holtslag H, van Beeck E, Lindeman E, Leenen L (2007) Determinants of Long-Term Functional Consequences After Major Trauma. Journal of Trauma 62: 919–927.
36. Stevenson M, Segui-Gomez M, Lescohier I, Di Scala C, McDonald-Smith G (2001) An overview of the injury severity score and the new injury severity score. Injury Prevention 7: 10–13.
37. Zou G (2004) A modified poisson regression approach to prospective studies with binary data. American Journal of Epidemiology 159: 702–706.
38. Rubin D (1976) Inference and missing data. Biometrika 63(3): 581–590.
39. Seaman SR, White IR (2013) Review of inverse probability weighting for dealing with missing data. Statistical Methods in Medical Research 22(3): 278–295.
40. Langley JD, Lilley R, Wilson S, Derrett S, Samarazayaka A, et al. (2013) Factors associated with non-participation in one or two follow-up phases in a cohort study of injured adults. Injury Prevention. Published Online First: 16 March 2013 doi: 10.1136/injuryprev-2012-040685.
41. StataCorp (2011) Stata: Release 12. Statistical Software. College Station, TX: StataCorp LP.
42. Smith D (2008) Disparities in health care access for women with disabilities in the United States from the 2006 National Health Interview Survey. Disability and Health Journal 1(2): 79–88.
43. Mauri Ora Associates (2010) Māori Experience of ACC: Mauri Ora Associates Final Report for Department of Labour 2010.
44. Rumball-Smith J (2009) Not in my hospital? Ethnic disparities in quality of hospital care in New Zealand: a narrative review of the evidence. New Zealand Medical Journal 122: 60–63.
45. Ratima K, Ratima M (2007) Māori experience of disability and disability support services. In: Robson B, Harris R, editors. Hauora: Māori Standards of Health IV: a study of the years 2000–2005. Wellington: Te Rōpū Rangahau Hauora a Eru Pītame, School of Medicine and Health Sciences, University of Otago, Wellington.
46. Robroek SJW, Reeuwijk KG, Hillier FC, Bambra CL, van Rijn RM, et al. (2013) The contribution of overweight, obesity, and lack of physical activity to exit from paid employment: a meta-analysis. Scandinavian Journal of Work, Environment and Health doi: 10.5271/sjweh.3534. [Epub ahead of print].
47. Tøien K, Skogstad I, Ekeberg O, Myhren H, Schou Bredal I (2012) Prevalence and predictors of return to work in hospitalised trauma patients during the first year after discharge: A prospective cohort study. Injury 43: 1606–1613.
48. Soberg H, Bante-Holter E, Roine O, Finset A (2007) Long-term multidimensional functional consequences of severe multiple injuries two years after trauma: A prospective longitudinal cohort study. Journal of Trauma 62: 461–470.
49. Holbrook TL, Hoyt DB (2004) The impact of major trauma: quality-of-life outcomes are worse in women than in men, independent of mechanism and injury severity. Journal of Trauma 56: 284–290.
50. Vlie W, Steyerberg E, Esink-Bot M-L, van Beeck E, Meuwis J, et al. (2005) Prevalence and determinants of disabilities and return to work after major trauma. The Journal of Trauma 56: 126–135.
51. Wilson R, Derrett S, Hansen P, Langley J (2012) Retrospective evaluation versus population norms for the measurement of baseline health status. Health and Quality of Life Outcomes 10: 68.
52. Overgaard M, Hoyer C, Christensen E (2011) Long-Term Survival and Health-Related Quality of Life 6 to 9 Years After Trauma. Journal of Trauma 71: 435–441.