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Workplace health and safety and the future of work: Evidence from linked-unit record data

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Workplace health and safety and the future of work: Evidence from linked unit-record data

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Abstract

Despite presenting potentially significant challenges and opportunities, the possible implications for workplace health and safety (WHS) of future-of-work trends have so far received scant attention. This paper, therefore, empirically examines the relationship between future-of-work trends and workplace injuries. It undertakes multivariate regression analysis using population-level accident compensation data for New Zealand linked to other data sources within Stats NZ's Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD), including information on business practices related to the future-of-work.

It finds that work-related injury claim rates tend to increase with age, which presents a potential challenge for WHS given the ageing workforce. The injury claim rate decreases as job tenure increases, suggesting that future-of-work trends that increase the rate of job switching, such as non-standard work and technological change, also present a challenge. Workers in industries such as agriculture and manufacturing have relatively high injury claim rates, suggesting that the ongoing shift away from these higher-risk industries and towards lower-risk service industries is positive for WHS outcomes. In addition, the finding that workers in firms with high levels of automation have lower injury claim rates highlights the potential of automation to remove workers from potentially hazardous situations. While workers in firms that offer flexible working arrangements, such as working from home, have lower injury claim rates, this is likely to be largely due to the nature of the jobs that are amenable to flexible work arrangements.

Keywords: workplace health and safety; work-related injury; future of work

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Disclaimer: These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD) which are carefully managed by Stats NZ. For more information about the IDI and LBD please visit https://www.stats.govt.nz/integrated-data/. The results are based in part on tax data supplied by Inland Revenue to Stats NZ under the Tax Administration Act 1994 for statistical purposes. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements. All observation counts have been randomly rounded to base 3 in according with Stats NZ confidentiality rules.

1 Introduction

What are the possible implications of future-of-work trends for workplace health and safety (WHS)? The future-of-work encompasses a confluence of meta-trends affecting how goods and services are provided and the ways in which people work. These include technological advances influencing the way goods and services are produced and delivered and the ways in which people work due to the ability to work remotely and the move away from a traditional employer-employee work relationship via trends such as platform/gig-economy work. It also includes globalisation, which is associated with trends such as the rise in global value chains and the increased global mobility of the factors of production, including workers. Social and demographic shifts, such as the ageing population and increasing female labour force participation, are also driving changes in the way people work through, for example, part-time and more flexible working arrangements.

Despite presenting potentially significant challenges and opportunities, the possible implications for WHS of future-of-work trends have so far received scant attention. This paper, therefore, empirically examines the relationship between future-of-work trends and workplace safety outcomes. It uses New Zealand (NZ) accident compensation data linked to other data sources within Stats NZ's Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD), which includes information from the Business Operations Survey 2018 (BOS 2018) module on the 'Changing nature of work'. This module includes firm-level future-of-work measures such as the degree of automation, whether the firm offers flexible working arrangements and the extent to which firms use non-standard employment arrangements.

2 Material and methods

We use linked administrative and survey data available in Stats NZ's Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD). These databases provide a rich set of population-level unit-record information on individuals and businesses. This includes information on all Accident Compensation Corporation (ACC) injury claims. It also allows us to link information on workers, which is available in the IDI, with information on their workplaces, which is available in the LBD, via the Linked Employer-Employee Database (LEED). This allows us to include explanatory variables on both the characteristics of individuals as well as the characteristics of the businesses they work in. This includes future-of-work variables available in an ad-hoc BOS 2018 module. A description of the explanatory variables and their sample means are presented in Appendix A.

2.1 Defining the population of interest

Our population of interest includes workers with observed Inland Revenue (IR) monthly 'wage and salary' income in 2018. The year 2018 was chosen to match the timing of the BOS 2018. The use of monthly (rather than annual) data allows us to more accurately link workers and their workplaces, and the associated injury claims. In the small number of cases where an individual worked for more than one employer in a given month, we assign the individual to one employer based on which job was their main source of income. This results in over eight million individual-month observations relating to about 910,000 individuals.

We further restrict attention to individual-month observations for which the employer has valid information within the BOS 2018 survey. We obtain information on firm-level future-of-work practices from the ad-hoc module on the 'Changing nature of work'. BOS covers a sample of firms with six or more employees, meaning workers in small firms are excluded. This results in almost 7.7 million individual-month observations relating to about 870,000 individuals.

2.2 Work-related injury outcome variable

For our population of interest, we use accepted work-related ACC injury claims as our outcome variable. Table 1 shows that of the almost 7.7 million individual-month observations, about 54,600, or 0.70%, had at least one accepted work-related injury claim. To give a sense of the severity of these injuries, the average associated medical cost was about NZD900 (in June 2018, the median weekly salary/wage income was just under NZD1,000). About 15% of claims involved compensated time off work in addition to medical costs, and the average number of days off work was about 6.7.

Table 1 Descriptive statistics: Work-related injuries based on ACC claims data

Variable	Definition	Mean
Any work-related injury claim	A dummy variable equal to one if the worker had at least one work-related injury claim during the month; zero otherwise.	0.704%
Total medical costs of all work-related injury claims	Sum of the medical costs to date for all work-related injury claims that occurred in that month.	NZD903.48
Any compensated days off work	A dummy variable equal to one if the claim involved any compensated time off work; zero otherwise.	15.48%
Number of compensated days off work due to work-related injury	Count of all the compensated days off work taken to date for work-related injury claims that occurred in that month (includes claims with zero compensation days).	6.68 days
Number of individual-month observations		**7,696,839**
Number of individuals		**872,019**

2.3 Data strengths and limitations

ACC data has the advantage that it includes the universe of accident claims. NZ's ACC system also has distinct features which mitigate under- and mis-reporting concerns. ACC is a compulsory universal, no-fault system where treatment providers, rather than the injured individual, submit treatment claims. Treatment providers include primary health practitioners, resulting in coverage of even minor injuries. These features should minimise underreporting issues relative to accident compensation systems in other jurisdictions. In practice, however, there does appear to still be a reasonable amount of underreporting. Poland (2018) estimates that about a third of those who report having an injury that stops them from doing their usual activities for more than a week do not

appear to have received any form of accident compensation (including treatment costs), which may be because the injuries were minor and therefore medical treatment was not sought.

ACC work-related injury claims likely reflect differences in actual injury rates and differences in the propensity to seek medical treatment in the event of an injury. For example, Poland (2018) finds that the degree of underreporting varies by age, ethnicity and occupation, likely reflecting differences in attitudes and access to healthcare treatment.

However, an additional strength of the ACC data stems from the fact that individuals are entitled to the same earnings compensation whether or not their injury is work-related. In other jurisdictions, earnings compensation is typically only available for work-related injuries. This feature of ACC should minimise incentives to misreport non-work accidents as being work-related.

One limitation of our study is that our population of interest does not include self-employed workers unless they pay themselves a wage/salary. While the IDI does contain self-employed income information (other than self-employed wage/salary earnings), it is generally only available on an annual basis, making it more difficult to accurately link workers and their workplaces in a time-consistent way as with monthly wage/salary data.

We focus on individual-level information that is available for the entire population via administrative data. We do not draw individual-level information from survey data because some of the key firm-level future-of-work variables will be drawn from survey data (via BOS 2018) and it is not possible to undertake robust analysis using survey sources from within both the IDI and LBD as there would be little sample overlap between the two. This inability to use multiple linked surveys means that we cannot include some individual-level characteristics that are not available via administrative data sources but are available via surveys, such as occupation, hours worked, highest qualification and years living in NZ for those who were not born in NZ.

A caveat of the BOS data is that it is a representative sample of NZ private enterprises with six or more employees. Therefore, BOS does not provide information on small firms, nor on public sector and not-for-profit organisations. Furthermore, the responses are also self-reported, and often in a yes/no format, and do not provide a sense of how and to what extent these policies and practices are implemented within the firm. In addition, the relevant questions in the 'Changing nature of work' module were only asked in BOS 2018, so no time series data are available on these variables.

2.4 Methodology

We estimate the conditional associations between individual and firm characteristics and workplace injuries using multivariate linear estimation models. This means abstracting from the binary nature of the outcome variable in order to simplify the estimation process given computational power limits and the large size of our datasets.[1]

Specifically, we estimate:

$$P(ACC_{\mathrm{ift}}) = \alpha + \beta_1 I_{\mathrm{it}} + \beta_2 \mathrm{IR}_{it} + \beta_3 F_f + \beta_4 BOS_f + \epsilon_{it}$$

where ACC_{ift} is an indicator of whether individual *i* working in firm *f* had at least one ACC claim in month *t*. To account for possible serial correlation of standard errors, these are clustered at firm-level.

As described in Table A1, the set of explanatory variables includes vectors for individual socio-demographic characteristics (I_i) (such as gender, age and ethnicity) and a vector for individual economic characteristics from IR tax data (IR_{it}) (such as job tenure, gross monthly earnings, multiple jobs held and an indicator for a change in employer). It also includes a vector for general

[1] Results were checked for their sensitivity with respect to the method choice. Standard logistic regressions as well as a rare events logistic regression framework (in order to take into account that only 0.7% of individual-month observations have an associated ACC claim) provide estimated coefficients, average marginal effects and significance levels that are very much in line with the estimates of the linear estimations.

firm-level characteristics from the LBD (F_f) (such as ANZSIC06 industry classification, firm size, firm age, overseas ownership rate and firm profits) and a vector for workplace practices and other more specific firm-level information from the BOS data (BOS_f), including future-of-work variables, as described in Table A2. In addition to the definitions of all individual and firm-level characteristics provided in Tables A1 and A2, are the means for our sample period.

3 Results and discussion

Table 1 presents the regression results for the binary outcome variable of any work-related ACC claim. Column 1 presents the results for all individuals, while Columns 2 and 3 restricts attention to male and female workers respectively, allowing for the possibility of coefficient heterogeneity.

Gender, age, ethnicity and migration status

Work-related injury rate differences by gender, ethnicity and migration status are relevant to the future-of-work as workforces are becoming more diverse. This reflects factors such as the increased labour force participation of women, a decrease in the prevalence of gendered jobs, and an increase in ethnic diversity and migration. Moreover, work-related injury rates by age are relevant given population ageing.

Women are approximately 0.29 percentage points less likely to have work-related ACC claims than men, even after controlling for other factors such as industry. This difference is sizeable - given an average individual-month injury claim rate of 0.70%, this equates to a 41% lower claim rate of 0.42%. This gender difference appears to contrast with evidence from Canada that lower workplace harm among women can largely be attributed to differences in industry and occupation (Smith & Mustard, 2004). However, while we have controlled for industry, because information on hours worked and occupation are not available at the population-level in the IDI, we cannot assess

whether the remaining gender differences are due to a greater prevalence of part-time work and/or less physical work among women.

In terms of age, the conventional wisdom is that the younger and older workers will have relatively high injury claim rates compared with those of prime working age. After controlling for other factors, however, workers aged 45-54 years are actually 0.08 percentage points more likely to have a claim than the comparison group of 15-24 year olds (i.e. 11% more likely given a mean injury claim rate of 0.70%), and those aged 55-64 are 0.13 percentage points less likely. There is no statistically significant difference between 35-44 year olds and the comparison group of 15-24 year olds, and similarly for workers aged 65 and over. The generally positive relationship between work-related injury claim rates and age suggests that the ageing population may pose challenges for workplace safety going forward. As with gender, it is possible that a greater prevalence of part-time work among young workers could also influence the results. Moreover, the higher injury claim rates among older workers may be underestimated given the finding of Poland (2018) that suggests underreporting of injuries is more prevalent among older people.

Injury claim rates also vary by ethnicity. Compared with European workers, Māori workers are 0.18 percentage points more likely to have an injury claim (i.e. 25% more likely given a mean claim rate of 0.70%), Pacific workers are 0.12 percentage points more likely, and Asian workers are 0.17 percentage points less likely. Again, we cannot assess whether the remaining differences are due to systematic differences in occupation. Also, as discussed in Section 2.3, these differences by ethnicity may partly reflect systematic differences in the propensity to seek treatment in the event of an injury.

The gender-specific regressions show that ethnic differences for females are, in general, less stark than those for men. Māori have higher work-related injury claim rates than Europeans in both the male and female regressions and the coefficients are of similar magnitude (0.17 and 0.16 percentage points respectively). However, the difference between European and Pacific women is only weakly

statistically significant and of smaller magnitude than the difference between European and Pacific men (0.13 percentage points for Pacific men and 0.05 percentage points for Pacific women). Similarly, while Asian females have a 0.09 percentage point lower likelihood of having an injury claim than European women, the magnitude of this difference is much smaller than between Asian and European men (0.22). While industry is controlled for, these gender differences could reflect that ethnic differences in occupations are greater for men than women, with more Māori and Pacific men working in physical and higher-risk occupations.

There are no statistically significant differences in injury claim rates between those who were and were not born in NZ. The international literature finds that migrant workers have higher rates of work-related injuries than native-born workers. Evidence suggests that while migrant workers are over-represented in more dangerous industries and occupations, even within occupational categories, migrants have higher injury rates (Ahonen et al., 2007; Schenker, 2010). NZ's situation may be different than that of many countries as NZ's immigration policy focuses on the intake of skilled migrants and, as a result, the relative education level among the migrant population is higher than in other countries (OECD, 2018). This likely means that migrant workers are less likely to work in high-risk industries/occupations in NZ than in other countries. However, international evidence from Canada, which has a similar skilled migration policy, finds that migrant men who had been in Canada for less than five years experienced twice the rate of work-related injuries relative to Canadian-born men (Smith & Mustard, 2009). They also find no difference in injury risk between migrant and Canadian-born women. Unfortunately, we do not have information on the amount of time migrants have lived in NZ so cannot investigate the possibility that results are different for recent migrants versus those who have been in NZ for several years.

Job tenure

Future-of-work trends, such as non-standard work and technological change, can increase the rate of job switching and therefore reduce job tenure. We find that the injury claim rate decreases with

job tenure, which is in line with expectations and consistent with international evidence (for example, Breslin & Smith, 2006; Morassaei et al., 2013). Relative to those with tenure of under a year, those who have a tenure of 1-3 years are 0.08 percentage points less likely to have an injury claim, those who have a tenure of 3-6 years are 0.17 percentage points less likely, and those who have a tenure greater than six years or more are 0.27 percentage points less likely. While it may be that those who switch employers often are different in general from those who do not switch as often, it could also reflect that those who stay longer with an employer have more experience in their role and a better handle on safety risks. However, since we cannot control for the nature of workers' jobs, it could also partly reflect that as employees stay longer with an employer, they change roles, and tend move to less physical roles over time (for example, by progressing from front-line to management roles).

The magnitude of the coefficients on tenure are larger for men suggesting a stronger association between injuries and tenure. For example, the probably of an injury claim for men who have a tenure of six or more years is 0.35 percentage points lower than the probability for men (which equates to a very large 50% lower injury claim rate given a mean claim rate of 0.71%). By comparison, women with a tenure of six or more years have a 0.17 percentage point lower probability of a claim (equating to a 24% lower injury claim rate).

Industry

Changes in industry structure are a feature of the future-of-work. In NZ, as in other countries, the share of employment in agriculture and manufacturing has decreased as the share in service industries, such as financial and insurance and professional services, has increased (New Zealand Productivity Commission, 2019).

Compared with the reference category of manufacturing, workers in the agriculture industry have a 0.18 percentage point higher probability of having an injury claim. Injury claim rates are lower than manufacturing in most service industries, such as wholesale trade (-0.25 percentage points), retail

trade (-0.39 percentage points), accommodation & food services (-0.26 percentage points), financial & insurance services (-0.42 percentage points), information media & telecommunications (-0.47 percentage points) and so forth. This is as expected since these tend to be lower risk industries, with a smaller share of workers undertaking physical jobs. There is no statistically significant difference in injury claim rates between male workers in the construction industry and those in the manufacturing industry, and the likelihood of having an injury claim is lower for female workers in the construction industry compared with manufacturing industry workers. Workers in the mining industry have a 0.33 percentage point lower probability of an injury claim than those in manufacturing. Although this seems surprising, results for the mining industry should be interpreted with caution due to the very small number of workers in the industry. There is no statistically significant difference between transport, postal & warehousing and manufacturing.

In general, the industry differences for men are stronger than for women. Again, this may be because we cannot account for occupation – for example, risk factors such as the difference in the degree of physical work undertaken by women in different industries may be smaller on average than the across-industry differences for men.

Firm size and age

There are no statistically significant differences in injury claim rates by firm size when all workers are examined together. The general view is that managing health and safety is more challenging for small firms who face resource constraints, less formal management styles and limited access to external support (for example, see MBIE, 2018). When the results are run separately for men and women, male workers in large firms with 250+ employees have a lower likelihood of an injury claim (-0.11 percentage points) compared with workers in firms with 6-49 employees, but the difference is only weakly statistically significant. For women, injury claim rates tend to increase with firm size. Female workers in firms with 50-249 employees are 0.08 percentage points more likely to have an injury claim than women in firms with 6-49 employees, and those in firms with 250+ employees are

0.14 percentage points more likely. Overall, the relationship between injury claims and firm size is not straightforward.

There are few differences in injury claim rates by firm age. For men, those who work in firms that are 5-9 years old are 0.16 percentage points less likely to have an injury claim than those who work in firms that are younger than five years. Those who work in firms that are 10-24 years old are 0.13 percentage points less likely to have an injury claim than those who work in firms that are less than five years old. There are no statistically significant differences by firm age for female workers.

Automation

Automation is a prominent future-of-work trend. As expected, workers in firms with higher levels of automation of physical tasks have lower injury claim rates. A one-point increase in the 0-4 degree-of-automation scale reduces the likelihood of having an injury claim by 0.08 percentage points for male workers. This is as expected and consistent with automation removing workers from potentially hazardous situations. However, there is no statistically significant difference for women, which may be because women are less likely to work in jobs with high injury risks and therefore benefit less from safety improvements due to automation.

Flexible working arrangements

Flexible work practices, such as working from home, flexible hours and part-time work, were already on the rise before Covid-19, and the resulting lockdowns appear to have been a catalyst to further normalise these practices. In terms of workplace safety, it is not clear whether this will increase or decrease work-related harm. Thinking about broader wellbeing outcomes (beyond just injuries), flexible work practices may have a positive effect on workers' wellbeing by reducing commuting time and contributing to work-life balance. On the other hand, flexible practices may increase psychosocial risks as they represent a move towards an 'always on' work culture as the traditional boundaries between home and work erode and may lead to isolation (Montreuil & Lippel, 2003). In terms of safety, while most activities that are amenable to work-from-home arrangements are

relatively low risk, such as office work, it is likely to be more difficult for employers to monitor and provide a safe working environment outside of the traditional workplace setting.

Workers in firms that offer work-from-home options have lower workplace injury claim rates, with the coefficient being larger for male than female workers. However, since we cannot control for occupation, this may reflect that firms with a higher share of workers in roles that are amenable to remote working and also carry a relatively low injury risk (such as professional and managerial roles) are more likely to offer work-from-home options. Female workers in firms with a flexi-time option have a lower likelihood of an injury claim, but there is no statistically significant difference for male workers.

Male workers in firms that have the option of part-time work have a 0.15 percentage point lower probability of a work-related injury claim than those that work in firms that do not have this option. Given that we cannot control for hours worked, this variable may be partially proxying for part-time work since workers in firms that offer the option of part-time work are probably more likely to actually work part-time. If this is the case, then the negative relationship between injury claims and the option of part-time work is unsurprising. However, the coefficient on this variable is not statistically significant for female workers.

Firm share of employment type

We investigate the composition of the type of employment of firms since non-standard work is a key future-of-work trend. The coefficient on the share of full-time workers in the firm is positive and significant for male workers but not female ones. As expected, workers in firms with a larger share of employees in management and professional positions have a lower claim rate. Similar to the case of the share of full-time employees, since we cannot control for occupation, this is likely to be a partial proxy for whether the worker is in a management or professional position, resulting in a negative coefficient. Again, the size of the coefficient for men is larger than for women. There is no

statistically significant relationship between the share of casually-employed and contract-for-service workers, which is interesting given workforce casualisation is a key future-of-work concern.

Influence of health and safety considerations on the firm

BOS asked firms to assess the extent to which health and safety considerations have influenced whether changes have been made to how the business is run in the last two years. Workers in firms who responded 'A great deal' have a 0.13 percentage point higher likelihood of an injury claim than those who work in firms that responded 'Not at all'. On the surface, this seems contradictory, but may reflect that firms with poorer safety records are more likely to have changed their practices in an effort to address these issues. Or, it could be that firms undertaking higher risk activities have higher injury claim rates and are also more likely to carefully monitor safety practices.

Employment engagement and voice

For the most part, there are no statistically significant differences between the injury claims rate for those who work in firms with various employment engagement practices and those who work in firms that do not have these practices. An exception is men who work in firms with employee feedback programmes (e.g. satisfaction surveys) have a 0.10 percentage point lower likelihood of having an injury claim than men who work in firms which do not have these programmes.

For men, relative to the base case of no employees being covered by collective agreements, workers in firms where 11-90% of workers are covered have a 0.19 percentage point lower probability of having an injury claim. There are no statistically significant differences by collective agreement coverage for women. Male workers in firms with employee feedback programmes also have lower injury claim rates. These variables likely reflect the amount of voice and bargaining power employees have within the firm, suggesting that greater voice reduces injury claim rates, at least for male workers. For women, having policies or practices to address pay gaps (including gender pay gaps) is associated with lower injury claims, however the result is not statistically significant for men.

Table 2 Regression estimates: ACC work-related injury claims

	All	Men	Women
	b/se (1)	**b/se (2)**	**b/se (3)**
Female	-0.288*** (0.017)		
Age (Ref.: 15-24 years)			
25-34 years	0.014 (0.016)	0.009 (0.023)	0.017 (0.017)
35-44 years	0.025 (0.018)	0.001 (0.026)	0.054** (0.019)
45-54 years	0.079*** (0.019)	0.026 (0.026)	0.147*** (0.021)
55-64 years	0.125*** (0.021)	0.100*** (0.030)	0.149*** (0.022)
65+ years	0.001 (0.025)	-0.038 (0.035)	0.036 (0.026)
Born in NZ	-0.010 (0.009)	-0.023 (0.014)	0.002 (0.011)
Ethnicity (Ref.: European)			
Māori	0.176*** (0.016)	0.167*** (0.022)	0.162*** (0.019)
Pacific Peoples	0.120*** (0.021)	0.134*** (0.030)	0.051* (0.023)
Asian	-0.168*** (0.016)	-0.219*** (0.021)	-0.099*** (0.016)
MELAA (Middle Eastern, Latin American or African)	0.013 (0.027)	-0.052 (0.039)	0.106** (0.036)
Other	0.037 (0.024)	0.047 (0.032)	0.030 (0.033)
Job tenure (Ref.: Less than 1 year)			
1-3 years	-0.082*** (0.014)	-0.118*** (0.019)	-0.046** (0.014)
3-6 years	-0.169*** (0.015)	-0.218*** (0.020)	-0.117*** (0.016)
6 years or more	-0.270*** (0.018)	-0.349*** (0.023)	-0.169*** (0.017)
Monthly gross earnings (Ref.: Less than $3,000)			
$3,000-4,500	0.181*** (0.014)	0.243*** (0.023)	0.116*** (0.014)
$4,500-6,500	0.015 (0.017)	0.034 (0.026)	-0.034 (0.018)
$6,500 and over	-0.254*** (0.021)	-0.282*** (0.030)	-0.145*** (0.018)
Other job-related			
Multiple jobs	0.012 (0.018)	-0.022 (0.027)	0.052* (0.021)
New employer	0.056*** (0.017)	0.070** (0.026)	0.039* (0.016)
Industry (Ref.: Manufacturing)			
Agriculture, Forestry & Fishing	0.177** (0.056)	0.132* (0.064)	0.253*** (0.064)
Mining	-0.332*** (0.070)	-0.383*** (0.073)	-0.231* (0.100)
Electricity, Gas, Water & Waste Services	0.034 (0.138)	0.148 (0.151)	-0.215* (0.102)
Construction	0.061 (0.049)	0.044 (0.050)	-0.248*** (0.048)
Wholesale Trade	-0.248*** (0.039)	-0.300*** (0.049)	-0.167*** (0.037)
Retail Trade	-0.385*** (0.043)	-0.559*** (0.057)	-0.154*** (0.044)
Accommodation & Food Services	-0.259*** (0.048)	-0.506*** (0.060)	-0.019 (0.044)
Transport, Postal & Warehousing	-0.082 (0.049)	-0.088 (0.057)	-0.059 (0.047)
Information Media & Telecommunications	-0.467*** (0.055)	-0.542*** (0.066)	-0.362*** (0.047)
Financial & Insurance Services	-0.424*** (0.050)	-0.501*** (0.069)	-0.340*** (0.041)
Rental, Hiring & Real Estate Services	-0.431*** (0.058)	-0.483*** (0.071)	-0.267*** (0.062)
Professional, Scientific & Technical Services	-0.389*** (0.038)	-0.508*** (0.046)	-0.217*** (0.044)
Administration & Support Services	-0.221*** (0.053)	-0.211** (0.068)	-0.181*** (0.046)
Education & Training	-0.282*** (0.083)	-0.485** (0.172)	-0.076 (0.059)

	All	Men	Women
	b/se (1)	**b/se (2)**	**b/se (3)**
Health Care & Social Assistance	-0.222*** (0.046)	-0.542*** (0.062)	-0.114** (0.042)
Arts & Recreation Services	-0.163 (0.087)	-0.173 (0.145)	-0.110 (0.060)
Other Services	0.070 (0.093)	0.073 (0.102)	-0.286** (0.101)
Firm size (Ref.: 6-49 employees)			
50-249 employees	0.010 (0.027)	-0.022 (0.036)	0.080*** (0.023)
250+ employees	-0.020 (0.037)	-0.119* (0.048)	0.141*** (0.033)
Firm age (Ref.: Less than 5 years)			
5-9 years	0.113* (0.044)	0.161** (0.055)	0.031 (0.037)
10-24 years	0.107* (0.045)	0.127* (0.056)	0.043 (0.038)
25-49 years	0.055 (0.047)	0.096 (0.058)	-0.012 (0.037)
50+ years	0.072 (0.054)	0.117 (0.064)	-0.002 (0.049)
Ownership, profit and automation			
Overseas ownership rate	-0.001*** (0.000)	-0.001*** (0.000)	-0.001** (0.000)
Firm profit (amount)	0.015 (0.014)	0.007 (0.019)	0.003 (0.009)
Firm profit (indicator)	-0.030 (0.031)	-0.015 (0.044)	-0.015 (0.027)
Automation of physical tasks	-0.074*** (0.022)	-0.080** (0.028)	-0.036 (0.018)
New automation of physical tasks	0.070 (0.040)	0.069 (0.050)	0.049 (0.039)
Flexible working arrangements			
Part-time work option	-0.117*** (0.028)	-0.153*** (0.035)	-0.029 (0.024)
Job sharing option	0.018 (0.024)	0.036 (0.032)	0.001 (0.020)
Shift work option	0.042 (0.025)	-0.001 (0.032)	0.110*** (0.021)
Flexi-time option	-0.074** (0.028)	-0.029 (0.036)	-0.132*** (0.028)
Work from home option	-0.145*** (0.026)	-0.210*** (0.033)	-0.043* (0.021)
Share of employees...			
...in full-time employment	0.002*** (0.000)	0.003*** (0.001)	0.001 (0.000)
…in management and professional positions	-0.003*** (0.001)	-0.004*** (0.001)	-0.002*** (0.000)
...in casual employment agreements	0.000 (0.001)	-0.000 (0.001)	0.001 (0.001)
...on service contracts	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Firm structure			
Utilised the gig / sharing economy	-0.098 (0.055)	-0.083 (0.066)	-0.116** (0.043)
Identifies as a Māori business	-0.012 (0.056)	-0.026 (0.064)	-0.006 (0.041)
Merger or shareholding acquired	-0.088* (0.038)	-0.081 (0.046)	-0.042 (0.029)
Equipment age (Ref.: Up to date)			
Up to 4 years behind	-0.008 (0.024)	0.009 (0.030)	-0.022 (0.020)
4-10 years behind	-0.035 (0.043)	-0.026 (0.052)	-0.045 (0.037)
More than 10 years behind	-0.140* (0.060)	-0.143 (0.076)	-0.100* (0.049)
Don’t know	-0.017 (0.027)	0.015 (0.033)	-0.051* (0.025)
Health and safety influence (Ref.: Not at all)			
A small amount	0.016 (0.035)	0.024 (0.049)	-0.012 (0.030)
A moderate amount	0.087* (0.037)	0.105* (0.049)	0.032 (0.032)
A great deal	0.130*** (0.035)	0.157** (0.048)	0.054 (0.030)
Don’t know	0.139** (0.049)	0.208** (0.071)	0.023 (0.045)

	All	Men	Women
	b/se (1)	**b/se (2)**	**b/se (3)**
Recruitment difficulties (Ref.: None)			
Moderate	0.007 (0.028)	0.002 (0.039)	-0.003 (0.025)
Severe	0.079* (0.031)	0.100* (0.042)	0.035 (0.028)
Don't know	-0.118* (0.048)	-0.078 (0.062)	-0.138*** (0.038)
Market competition (Ref.: Many competitors, several dominant)			
Captive Market / No effective competition	-0.101* (0.046)	-0.143* (0.069)	-0.038 (0.036)
1-2 competitors	0.014 (0.028)	-0.002 (0.035)	0.033 (0.026)
Many competitors, none dominant	-0.013 (0.031)	-0.020 (0.038)	-0.009 (0.027)
Don't know	0.109 (0.087)	0.075 (0.103)	0.189* (0.083)
Change in market share (Ref: Stayed the same)			
Decreased	0.001 (0.036)	0.009 (0.045)	-0.012 (0.030)
Increased	0.017 (0.025)	0.004 (0.032)	0.010 (0.021)
Don't know	-0.007 (0.026)	0.001 (0.034)	-0.044* (0.022)
Share of employees covered by collective agreements (Ref.: None)			
1-10%	-0.031 (0.036)	-0.040 (0.046)	-0.009 (0.029)
11-50%	-0.077* (0.034)	-0.126** (0.046)	-0. 045 (0.028)
51-90%	-0.127** (0.046)	-0.188** (0.060)	-0.029 (0.040)
91-100%	-0.012 (0.050)	-0.026 (0.069)	0.001 (0.041)
N/A	-0.097 (0.057)	-0.160* (0.068)	0.006 (0.049)
Employee engagement			
Decision making	0.028 (0.023)	0.057* (0.028)	0.001 (0.020)
Health and safety	0.065 (0.060)	0.013 (0.078)	0.066 (0.048)
Feedback programmes	-0.071** (0.026)	-0.097** (0.032)	-0.023 (0.027)
Performance reviews	-0.015 (0.041)	0.022 (0.043)	-0.059 (0.049)
Training and mentoring programmes	0.065 (0.037)	0.052 (0.050)	0.061 (0.031)
Policies and practices			
Pay gap policy	-0.044 (0.027)	-0.013 (0.035)	-0.078*** (0.022)
Ageing workforce policy	0.032 (0.025)	0.017 (0.031)	0.049* (0.022)
Bullying policy	-0.052 (0.031)	-0.064 (0.039)	-0.005 (0.030)
Diversity and inclusion policy	-0.037 (0.028)	-0.053 (0.037)	0.011 (0.026)
Leave and childcare arrangements			
Buy extra annual leave / unpaid leave	-0.003 (0.026)	0.002 (0.033)	-0.008 (0.022)
Care leave	0.016 (0.031)	0.029 (0.040)	0.006 (0.026)
Childcare allowance or facilities	0.090** (0.033)	0.074 (0.042)	0.076** (0.028)
Parental leave provision	-0.008 (0.027)	0.001 (0.034)	-0.042 (0.022)
Constant	1.128*** (0.085)	1.270*** (0.109)	0.577*** (0.076)
Cluster level	**firm**	**firm**	**firm**
Observations	**7,696,755**	**4,318,317**	**3,378,438**
Share	**0.697**	**0.844**	**0.509**
R^2	**0.00311**	**0.00380**	**0.00163**

Notes: b/se are the estimated beta coefficient and standard error respectively. p-values: *, **, *** represent statistically significant differences at the 10%, 5% and 1% levels respectively. Standard errors are clustered to account for serial

correlation. Firms with missing profit information were assigned a profit value of zero and an indicator for missing profit information was also included.

4 Conclusion

This paper examines the relationship between future-of-work trends and workplace injury outcomes. It uses a rich database of NZ population-level accident compensation data linked to other individual- and firm-level data, including the Business Operations Survey 2018, which included information on future-of-work business practices, such as automation and flexible work arrangements.

It finds that some trends, such as an ageing workforce and an increase in the rate of job switching, will pose challenges for workplace health and safety going forward. However, automation and changes in industry structure will likely decrease work-related injuries. While workers in firms that offer flexible working arrangements have lower injury claim rates, this may be due to the nature of the jobs that are amenable to flexible arrangements rather than signalling that the increasing use of these arrangements will reduce work-related injuries.

Ethical statement: Our study uses secondary data and approval to conduct this study was obtained from Stats NZ. Ethics approval was not required as the National Ethics Advisory Committee's Ethical Guidelines for Observational Studies permit the use and linking of routinely collected anonymised data for observational studies without consent.

Declarations of interest: None

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Appendix A

Table A1 Individual-level explanatory variables: Definitions, sources and characteristics

Variable	Definition	IDI source	Category	Mean
Female	Dummy equal to one if identified as female; zero otherwise.	Personal details		0.44
Age	Set of dummy variables equal to one if the individual's age is within of the following age groups, and zero otherwise. Underlying continuous age is as at 30 June 2018 and is calculated based on the month and year of birth (day of birth is unavailable in the IDI).	Personal details	15-24	0.14
			25-34	0.24
			35-44	0.20
			45-54	0.21
			55-64	0.15
			65 and over	0.05
Ethnicity	Set of dummy variables equal to one if prioritised ethnicity was identified as being one of the following ethnicities, and zero if European only: Māori; Pacific Peoples; Asian; Middle Eastern, Latin American or African (MELAA); Other. Prioritised ethnicity - Respondents are allocated a single ethnicity where the order of priority is in accordance with the list above.	Personal details	Māori	0.15
			Pacific Peoples	0.09
			Asian	0.17
			MELAA	0.02
			Other	0.02
			European	0.55
Born in NZ	Dummy variable equal to one if born in NZ, i.e. observed in DIA birth records; zero otherwise.	Department of Internal Affairs - Birth records		0.62
Multiple jobs	Dummy variable equal to one if observed to receive earnings from more than one employer in the respective month; zero otherwise.	IR tax data		0.05
New employer	Dummy variable equal to one if changed employers during the month. This can involve a change in employer or a move from not being employed to being employed. We cannot observe if individuals changed jobs/roles within a business, and therefore did not switch employers.	IR tax data		0.09
Job tenure	Number of continuous months that the individual has been employed by the same firm.	IR tax data		56.37 months
Monthly gross earnings	Gross wages/salaries from the main job (sum of all payments by one employer) in respective month.	IR tax data		$5,538.69

	Main job is defined as the job with the main / highest source of income based on tax code M (or equivalent). If no job or multiple jobs have the tax code M, the job with the highest income is assumed to be the main job.			
Number of individual-month observations				**7,696,839**

3 **Table A2 Firm-level explanatory variables: Definitions and characteristics**

Variable	Definition		Category	Mean
	General characteristics			
Firm size	Twelve month moving average of the enterprises' monthly employment count.	Business Register data		108.1
Firm age	Age of the business on 30 March 2018 based on the birth date of the business.			19.17
Industry	Set of dummy variables equal to one if business is in one of the 18 ANZSIC level 1 industry categories; zero otherwise.		Agriculture, Forestry & Fishing	0.09
			Mining	0.01
			Manufacturing	0.21
			Electricity, Gas, Water & Waste Services	0.02
			Construction	0.06
			Wholesale Trade	0.08
			Retail Trade	0.05
			Accommodation and Food Services	0.04
			Transport, Postal & Warehousing	0.04
			Information Media & Telecommunications	0.03
			Financial & Insurance Services	0.05
			Rental, Hiring & Real Estate Services	0.02
			Professional, Scientific & Technical Services	0.1
			Administration & Support Services	0.06
			Education & Training	0.03
			Health Care & Social Assistance	0.06
			Arts & Recreation Services	0.02
			Other Services	0.03
Overseas ownership rate	Share of the enterprise which is owned by overseas persons or firms; zero if no overseas shareholders.			13.3
Firm profit (amount)	Annual gross profits for those firms with available information.			$4,243.61
	Automation			
Physical task automation	Scale of the degree of automation in the business's routine and non-routine physical tasks. For routine and non-routine physical tasks, the scale assigns a score between 0 (none) and 2 (fully) and sums the two scales to give a score that ranges from 0 to 4 (from no automation of routine and non-routine physical tasks	BOS 2018 (Business Operations Survey 2018)		0.42

	to full automation of both routine and non-routine physical tasks).			
New automation of physical tasks	Dummy for whether the business introduced any new automation which was most significant to routine or non-routine physical tasks (only asked of businesses who introduced any new automation in the last 2 years).			0.08
	Flexible working arrangements			
Part-time work option	Dummy for whether the business provides part-time work options.	BOS 2018		0.57
Job sharing option	Dummy for whether the business provides job sharing options.			0.20
Shift work option	Dummy for whether the business provides shift work options.			0.28
Flexi-time option	Dummy for whether the business provides options for flexible start and finish times.			0.61
Work from home option	Dummy for whether the business provides options to work from home.			0.35
	Share of employees…			
…in full-time employment	Share of employees in full-time positions (30 hours or more a week).	BOS 2018		0.80
…in management & professional positions	Share of employees in managerial or professional positions.			0.20
… on different contract types	Share of the firm's workers employed on different contract types.		Permanent	0.80
			Fixed-term	0.05
			Casual	0.11
			Contract for services	0.04
…covered by collective employment agreement	Set of dummies for the share of employees covered by a collective employment agreement.		None	0.71
			1-10%	0.05
			11-50%	0.05
			51-90%	0.04
			91-100%	0.11
	Firm structure			
Utilised the gig / sharing economy	Dummy for whether the business utilised the gig or sharing economy to provide goods or services to customers in the last 2 financial years.	BOS 2018		0.02
Identifies as a Māori business	Dummy for whether enterprise considers itself to be a Māori business.			0.04

Mergers and acquisitions	Dummy for whether the business merged with or acquired a shareholding in another business in the last financial year.			0.04
	Assets			
Equipment age	Set of dummies for how the business's core equipment compares with the best commonly available technology.	BOS 2018	Fully up to date	0.45
			Up to 4 years behind	0.27
			4-10 years behind	0.1
			> 10 years behind	0.03
			Don't know	0.15
	Health & safety and recruitment			
Health and safety influence	Set of dummies for the extent to which health and safety considerations have influenced whether changes have been made to how the business is run in the last 2 years.	BOS 2018	Not at all	0.11
			A small amount	0.23
			A moderate amount	0.31
			A great deal	0.31
			Don't know	0.04
Recruitment difficulties	Set of dummies for the extent to which the business experienced recruitment difficulties in the past year.		None	0.14
			Moderate	0.41
			Severe	0.36
			Don't know	0.08
	Market			
Market competition	Set of dummies for the self-assessed strength of the competition faced by the business.	BOS 2018	Captive market / No effective competition	0.04
			1-2 competitors	0.17
			Many competitors, none dominant	0.16
			Many competitors, several dominant	0.59
			Don't know	0.05
Change in market share	Set of dummies for the change in the business's market share in the last year.		Decreased	0.08
			Stayed the same	0.39
			Increased	0.27
			Don't know	0.26
	Employee engagement			

Decision making	Dummy for whether the business has practices in place for employee engagement in regular decision making.	BOS 2018		0.58
Health and safety	Dummy for whether the business has practices in place for employee participation in health and safety.			0.90
Feedback programmes	Dummy for whether the business has employee feedback programmes (e.g. satisfaction surveys)			0.52
Performance review	Dummy for whether business conducts performance reviews.			0.81
Training and mentoring programmes	Dummy for whether the business has training and mentoring programmes.			0.77
	Policies & practices			
Pay gap policy	Dummy for whether the business has pay gap policies or practices in place.	BOS 2018		0.22
Ageing workforce policy	Dummy for whether the business has ageing workforce policies or practices in place.			0.22
Bullying policy	Dummy for whether the business has bullying policies or practices in place.			0.67
Diversity and inclusion policy	Dummy for whether the business has diverse and inclusive workplace policies or practices in place.			0.47
	Leave & childcare arrangements			
Buy extra annual leave / take unpaid leave	Dummy for whether the business allows employees to buy extra annual leave or take unpaid leave	BOS2018		0.61
Care leave	Dummy for whether the business allows employees to take sick, unpaid or compassionate care leave to care for other people who are sick.			0.71
Childcare allowance or facilities	Dummy for whether the business provides some sort of childcare allowance or facility.			0.09
Parental leave provision	Dummy for whether the business provides parental leave beyond statutory requirements.			0.19
Number of firms				**6,456**

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