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# Into The Woods

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**Abstract**. New Zealand forestry workers have a higher likelihood of being injured or killed in the workplace than workers in any other industry. Despite investigations, reviews and recommendations, the statistics continue to worsen year by year. We believe that in order to fully understand the reasons for this we need to undertake large-scale data collection of workers and the wider context of their working, and personal conditions. To perform such data collection in an unobtrusive manner we propose the use of lightweight, wrist-worn activity trackers. In this paper we discuss our initial plans for conducting such data-collection and the problems and challenges presented by the forestry environment.

## 1 Introduction

The New Zealand forestry industry has the highest fatality and injury rate of any industrial sector in NZ. Thirty-two workers have been killed since 2008 and for the past three years both death and injury rates have continued to increase. An independent review has been conducted, and results published October 2014 [1]. Data was gathered through interviews and self-reporting of all involved in the sector, from forestry owners down to the workers themselves. The report identified a number of factors such as worker fatigue, lack of training, poor health and safety cultures in the workplace etc. and made eleven recommendations. These were mostly based on the creation of processes, action groups and codes of practice to support and increase participation in training and certification for workers and contractors. However, no strategy was recommended for how the underlying causes might be identified or monitored, nor were any practical solutions for the unsafe work practices identified or questions asked as to why these continue to exist.

Existing research into reducing accidents in forestry are focussed in two key areas. The first is increasing mechanisation in the industry through improved technological advancements that will enable more machinery to be used in NZ's extreme terrain. The second is through increased health and safety and worker management. Whilst both of these have the potential to improve safety within the industry, we believe that there are additional factors that need to be studied and taken into account, we discuss this next.

## 2 Data Collection for Identifying Potential Hazards

A common theme that is seen in the independent review, and comes up in conversations with both workers and management in the forestry industry is that of the workers' high physical workload coupled with tiredness and fatigue. We distinguish these as tiredness being a cognitive state associated with lack of sleep and fatigue being a physical and cognitive state associated with high levels of activity. Anecdotally a forestry worker's daily physical exertion is equivalent to that of running a half-marathon. Forestry workers are working in outdoor environments where they may face extreme temperatures and weather conditions during long working hours without the necessary hydration and/or nutrition.

In order to understand the genuine effects of tiredness and fatigue in a physically demanding work environment and their contribution to accidents we believe that the first step is a large-scale data gathering exercise which enables the existence and effects of tiredness and fatigue to firstly be validated so that, secondly, we can begin to understand how we might use this knowledge to make the workplace safer. We also believe that factors outside of the work environment may be equally influential, so if for example, workers have poor sleep patterns and are already tired at the start of the working day, this may exacerbate the work-generated fatigue and tiredness.

## 3 Problems with Data Collection In Forestry

Trying to measure worker activity levels by observing them during the working day is inherently problematic. Known factors such as the Hawthorne Effect [2] can alter behaviours of workers who are being observed. Additionally, in high-risk work environments such as forestry, the presence of researchers can contribute to safety problems. In [3] Parker attached video cameras to forestry workers in order to try and 'observe' different work practices of novice vs. experienced workers. Initially he tried to perform the study by personally observing workers in their work environment. However, it was soon clear that what he spent most time observing was the workers trying to make sure he did not get injured or in the way – the focus of their attention switched to keeping him safe. As we are also interested in collecting data outside of working hours, for example sleep data, it is neither practical nor ethical to propose doing this via researcher observation.

In order to resolve these practical issues we investigated the use of lightweight, low-cost activity trackers (e.g. FitBit, www.fitbit.com, JawBone www.jawbone.com etc.) to collect data on the activity levels of workers, both

in and out of work, as well as sleep data. Activity trackers would enable us to collect data from large numbers of workers who may be in remote locations, in a cost-effective, efficient and accurate manner.

Our initial period of research was spent analysing various activity trackers in order to compare differences in their functionalities and accuracy in measuring different tasks (including sleeping, step counting and the effect of activities such as driving or operating a chain-saw). This analysis took place in-house and was performed by the researchers in order to make some initial decisions about which devices we should use for our first studies with actual forestry workers. Deciding which devices to evaluate is not an easy task in itself. New devices come onto the market monthly, with increasing functionalities and claims of effectiveness. At the time our first studies were performed we were analysing what were considered 'market leaders' for devices in the less than NZ$200 range (which was our maximum price point). These were devices that measured both sleep and step counting, had some analysis (based on user metrics and steps) for calorie burn, and in the case of one device (the Withings Pulse) the ability to measure heart rate.

Since these initial studies all of the leading devices now come with heart-rate measurement and more accurate calorie burn measurements, and no doubt by the time we have completed our next study these will also be out of date – in fact one of our recent experiments had been to place a heart-rate enabled tracker inside a baseball cap to see if it could still effectively measure steps and heart-rate (with the aim of looking at incorporating devices into work safety gear) – and there are now at least two commercial versions of this available on the market for less than US$200 (SmartCap from spreewearables.com and SmartHat from life-beam.com).

In order to consider both activity levels and sleep quality for workers we wanted them to wear the activity trackers 24 hours a day, but we found that many devices recorded activities such as driving – particularly on rough, unsealed roads - as steps. There is no way to identify from the data provided how much of the activity recorded is from walking and how much from other activities such as driving. We found that for most devices, operating a chainsaw to fell trees did not trigger step-counting (although the action of slicing a felled tree did).

Generally the step-counting of all of the devices was at least consistent (if not 100% accurate) with the above exceptions. Sleep-tracking was much more inconsistent and it was not clear that any of the devices or phone apps we experimented with were providing accurate data.

Once we had narrowed down the devices that seemed most appropriate, we planned a small-scale pilot study with a couple of forestry workers to see how

well the trackers would perform in our real-world scenario. There are, of course, serious ethical considerations for this sort of monitoring which includes data from outside of the work environment. Whilst it is our intention to use the data from these studies in an anonymous fashion to set safe benchmarks for sleep and workloads, increasingly these types of trackers are being used to monitor workers for performance and management reasons [4]. In order to ensure our studies are conducted in suitably ethical ways we must ensure that all parties (both workers and the management layers above them) are clear about the nature of the data we can report back and the format we will provide it in. Similarly we need to find ways of reassuring the workers themselves that this type of data will not in any way be used 'against them' to try and show they are behaving in an inappropriate way (e.g. slacking off at work or partying all weekend).

Gaining permission to conduct our studies and finding willing participants also required navigating the overly complex hierarchy of forestry owners, managers, contractors and health and safety bodies. Most workers are employed by small contractors who provide work for companies that represent forestry owners, so there is no clear-cut management layer and permission and consent is required from all of the various bodies concerned.

One final consideration that cannot be overlooked is the demographic nature of the forestry workforce (predominantly male; young; from Māori or Pacific Island heritage) compared to that of the research team (female; Welsh, German and American and over the age of 40).

## 4 Technical Challenges

Our initial pilot study with forestry workers consisted of two workers wearing different trackers (one Fitbit Flex and one Jawbone UP) for a period of two weeks. We visited the workers at their employer's premises to set up the study and to provide them with information about how/when to charge the devices and to agree a time when we could contact them by telephone every few days in order to resolve any problems. Their work location (a three and a half hour round trip for us) meant that we could only meet with them in person once a week. At the end of the first week we met with the workers to collect the initial data, we had been unable to contact them on the provided phone numbers during the previous week. One of the devices had a flat battery and the other was very low (neither had been charged in accordance with the provided schedule). We swapped out both of the devices for fully charged equivalents and re-iterated the importance of charging every 4-5 days. During the second week we were still unable to speak to the workers on the phone, but

found that if we texted them instead we did get a response. The data from the first week was very incomplete. One of the workers had failed to put the device into sleep mode on any of the nights and was confused by the limited LED display and the other worker had (inadvertently) put his device in and out of sleep mode several times a day and during the night; as such, it was hard to accurately calculate sleep time for either worker.

The full set of problems encountered with the three week pilot were: trackers not put into sleep mode so sleep data patchy or missing entirely; trackers not charged regularly so missing data for one or two days at a time; one tracker lost temporarily in the first week, another lost in week three for one; the charging and data connector for one device was lost and never recovered.

It is possible that problems encountered with this initial study - lost devices, inability to change modes, lack of charging – may have underlying causes other than technical challenges. We need to be mindful of the fact that whilst their manager was keen to be involved in the study and had recommended these two workers as suitable participants (and they seemed keen to participate), the reality of being monitored in this way, particularly outside of work hours, may have been uncomfortable for them. We are not suggesting that there was any attempt to 'sabotage' this study, but it is certainly a possibility that may occur, particularly in larger studies. The issue of data anonymity was pertinent to this first study as we were only using two workers as our sample study. While their manager was keen to see the data to understand the workloads they were under, it was difficult for us to provide anything more general than the average step count per day for the workers combined without breaking privacy constraints.

## 5 Our Next Investigations

Despite the problems we encountered with our pilot study it was informative in enabling us to set and manage expectations for future studies. One of the things that has become clear is that the practice of monitoring worker's sleep patterns (even for short periods of time as an investigative option) is fundamentally problematic both from a practical as well as an ethical perspective. In order to be able to use such data as an indicator of potential danger in the working environment it would require both a long-term initial data gathering period (to set base-lines for individual workers) as well as on-going monitoring so that changes from the baseline could be identified. Again, the ethics of this sort of monitoring (even if the intention is to improve safety) is questionable.

Of most interest to us is the effect that fatigue and tiredness have on workers, particularly their response times, as this is what may enable detection of potentially hazardous situations. Our next studies, therefore, are focussed on looking at ways of measuring these response times and understanding the effect that fatigue may have. For example if a worker is performing a particular task which leads to fatigue, which in turn affects their response times, this might be used to better inform forestry management as to how tasks should be allocated throughout the day.

We are currently undertaking a survey of around 30 forestry workers to gain some information about how they feel they are affected by fatigue and tiredness. This will be followed by another small-scale pilot study where we will use a response-measuring app to record worker response times at three different points during the day, whilst also recording activity (steps) and heart-rates during the working period. The researcher for this project (a male, MSc student who lives within a half hour drive of the workers' location) will meet with the workers several times a day (for a period of one week) to perform the response tracking and collect the data from the activity trackers. The researcher will also be responsible for charging the trackers at night when necessary to ensure that data can be collected each day. This will help mitigate some of the problems we saw with our previous pilot study.

We have, however, already run into our first problem with this study, that of ensuring the researcher has correct personal liability insurance to be covered whilst in the forestry environment. No doubt as the study progresses we will uncover further issues of interest. In addition, one of the Health and Safety organisations involved in the forestry domain has offered to supply an additional quantity of activity trackers to be used as part of this study so that a larger number of workers can be surveyed. This, however, raises questions about data privacy (who do the devices 'belong to' and who has access – and ownership – of the data captured) and is yet another hurdle we need to navigate before this study begins.

## 6 Conclusions

In this paper we have briefly described an on-going research project which aims to perform large-scale data collection of forestry workers. We have also outlined the main problems encountered with this sort of research, which includes technical, ethical and sociological factors. We have identified some 'solutions' which we have adopted for our next proposed studies (for example the use of an in-situ researcher on a daily basis to help mitigate some of the

technical challenges), however we also expect to uncover further challenges as we progress with this, and subsequent studies.

It is likely that there are other research environments which contain similar challenges and we look forward to the opportunities of discussing these and sharing solutions.

## References

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