

HEALTH AND SAFETY PRACTICES ON CHRISTCHURCH'S POST-EARTHQUAKE REBUILD PROJECTS: HOW RELEVANT IS HEINRICH'S SAFETY PYRAMID

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Health and Safety is at the forefront of the construction sector projects in New Zealand particularly as the post-earthquake rebuild gets underway in Christchurch. Health and Safety best practice on all project sites needs to be constantly reviewed, updated, and implemented to reduce on-site accidents. The research investigated whether Heinrich's (1931) Safety Pyramid was relevant to Christchurch's post-earthquake rebuild projects in the civil construction sector. The selected literature specifically focussed on publications that involved or reviewed the validity of Heinrich's Safety Pyramid. Archival accident data in New Zealand for the year ending June 2103 was reviewed and to complement this data a questionnaire was prepared, and distributed to one hundred construction personnel working on civil construction rebuild projects in Christchurch in the latter part of 2013. In addition, semi-structured interviews were subsequently conducted with five selected personnel including project managers, supervisors and labourers. The reviewed and collected data were analysed with the resultant finding that Heinrich's Safety Pyramid was still considered to have relevance for safety practices on Christchurch's post-earthquake rebuild projects in the civil construction sector.

Keywords: Christchurch, civil construction rebuild, health and safety, Heinrich pyramid, post earthquake.

INTRODUCTION

Health and Safety New Zealand

The New Zealand Government is currently reviewing the Health and Safety system in New Zealand. Funding for an additional \$37 million over four years is being provided to help change the system by strengthening the approach and increasing frontline Health and Safety inspectors. This funding will also support targeted Health and Safety initiatives. The Government has set a minimum 25% reduction in workplace serious harm accidents and fatalities by 2020 and an interim target of a 10% reduction by 2016. In addition there is an independent task force reviewing whether the current Health and Safety systems in New Zealand are the optimal systems and will recommend any improvements.

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Rationale

According to the Canterbury Rebuild Safety Charter (2011), it is estimated that 1-2 construction workers may die each year from the re-build of Christchurch city if current statistics are any indication. This would cost over \$80 million in Accident Compensation Corporation (ACC) costs and 600,000 hours of lost time. This would put added pressure on the re-build that is avoidable. Steps are being taken to find ways of reducing these potential statistics. In early 2013 Christchurch accounted for half of all of the serious injuries reported in New Zealand. This research investigated a theory and tool that has been in use by companies to monitor and measure Health and Safety and accidents in particular on construction sites for many years, the Heinrich (1931) Safety Pyramid. Health and Safety training for the majority of workers completing the post-disaster civil construction re-build in Christchurch use accident pyramids to illustrate accidents from near misses to major incidents. Near-miss reporting is considered critical to Health and Safety success. Establishing whether the Heinrich Safety Pyramid was still relevant in the post-earthquake civil construction rebuild would inform decisions regarding Health and Safety policies in New Zealand.

LITERATURE REVIEW

In 1931 Herbert Heinrich wrote a book that became the foundation for Health and Safety regulations and culture throughout the construction industry worldwide. The work entitled 'Industrial Accident Prevention' described Heinrich's research into accidents as a result of working for 'Traveller's Insurance', and identified why and how industrial accidents occur, and could have been prevented. The findings were based on the analysis of 5000 cases of closed-claim-file insurance records of industrial accidents and company records. Heinrich's book introduced the ratio 1-29-300 which identified that in a unit group of 330 similar accidents, 300 will produce no injury whatsoever, 29 will result in only minor injuries and 1 will result in serious injury" (Heinrich 1931). This ratio became known as Heinrich's Triangle, or Heinrich's Pyramid. The three main statements underlying the Heinrich Triangle /Pyramid (1931) are summarised as:

1. A stable ratio of minor incidents (no injury), to moderate to major injuries following accidents,
2. The investigation of minor/no injury accidents provides valuable information to prevent further accidents,
3. Changes in the frequency of minor injuries cause a proportional change in harm.

The injuries resulting from accidents were placed in the following categories:

1. Major injuries -any case reported to insurance carriers or to the state compensation commissioner. This would be the equivalent of the New Zealand department of Labour (formally Occupational Safety and Health).
2. Minor injuries -a scratch, sprain, or cut. These incidents would commonly be termed a first-aid case.
3. No injury accidents -an unplanned event involving the movement of a person or an object, or substance (slip, fall, flying object, inhalation), and having the probability of causing personal injury or property damage, now referred to as a 'near- miss' (Heinrich 1931).

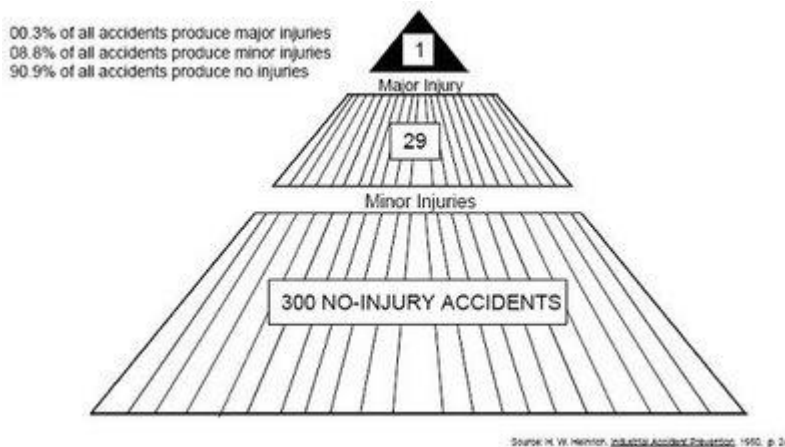


Figure 1 Heinrich's Safety Pyramid.

The ratio and categories are used widely throughout construction and other safety sectors. “*Heinrich is credited with bringing attention to workplace safety and focusing on the human element of safety*”, (Collins 2011).

One of the most important principles of Heinrich’s original pyramid is that fatalities cannot occur without a foundation of less severe incidents. That means that an increasing number of non-serious accidents will eventually mean that more serious accidents or major accidents will occur. This is the theory/ principle being reviewed in this research, with the question: Is Heinrich's Safety Pyramid still relevant in today’s construction sector health and safety environment on the Christchurch post-earthquake civil construction rebuild projects?

The reviewed literature clearly supported, or did not support the continued relevancy of the Heinrich's Safety Pyramid. McCaughey *et al.* (2010), and Klienfdorfer *et al.* (2011), stated that “*just because you have a good safety record does not mean that you are safe*”. Complacency seems to be a major concern as safety managers and on-site workers seem to relax more once the companies safety record has a high standard. ”

Gallivan *et al.*, (2008). disagreed with Heinrich’s theory that “*introducing measures to reduce the incidence of minor incidents will not inevitably reduce the incidence of major incidents*”, and further stated that, “*any safety policies based on the assumption that the Heinrich ratio is true needs to be rethought*”.

Smith (2006) questioned the way safety is measured, stating that “*it is impossible to measure the effectiveness of proactive methods of safety management*”. Reactive statistics (feedback received on an introduced system/product), are given bad press because they are seen as measuring failure. Smith (2006) believed that there are several advantages to reactive statistics versus proactive statistics (data collected via interviews with potential users of a system/product):

Proactive statistics are a measurement of fact, are specific, quantifiable, and can be used as a benchmark performance indicator compared with other companies, either within the same sector or industry wide. Proactive statistics allow accurate re-tracing of multiple casual events to pinpoint the times and places where effective interventions could have been made (Smith 2006).

An article written by Krause (2011) entitled, 'Where to now?' highlighted research that showed a reduction in minor injuries does not necessarily produce a reduction in serious injuries and fatalities. Krause (2011) further stated that, “*this contradicts a*

decade old paradigm in the safety community which has held that reductions in minor injuries produce proportional reductions in serious injuries”.

A number of safety managers continue to support Heinrich’s work and still use his Safety Pyramid for example, Paradies (2012) wrote the article 'Does the safety pyramid still exist?' Paradies noted that even though several safety managers were discrediting the pyramid, that the ratio should not be taken so literally, and should instead focus on the underlying theories, and that *“the focus of resources must be kept on minor problems that could lead to major accidents, and to stop wasting time on ‘paper cuts’ ”*. Gamble and Proctor's Port Ivory Study (2012), revealed a close similarity to Heinrich’s model, and even though Heinrich’s original pyramid has been adapted over time, the Safety Pyramid is still considered to have relevance for today's health and safety managers. "

“Heinrich’s triangle became the foundation on which many of today’s industrial accident prevention programs are built and perhaps the most important lesson learned from this foundational work is that the path that leads to the prevention of accidents resulting in major injuries, lies in investigating all accidents, including no-injury accidents” (Collins, 2011).

To conclude, Heinrich (1931) described two approaches in accident prevention and that both are required: 'an immediate approach' - the control of personal performance and the environment, and 'a long-term approach' involving training and education. Heinrich also noted that, *“accident prevention is both a science and art, and that a strict concentration on mathematical formulas and models do not create a safe environment”* (Heinrich, 1931).

RESEARCH METHOD

A multi-method approach was used for this research as it afforded collecting, analysing and integrating data from several sources. The three methods selected were post-earthquake accident archival data, questionnaires and subsequently selected semi-structured interviews, with five selected civil construction personnel.

Firstly, a statistical analysis of SCIRT's (Stronger Christchurch Infrastructure Rebuild Team) accident data was undertaken to find if there was any correlation between Heinrich’s Safety Pyramid and the recorded accidents in post-earthquake civil construction rebuild projects. SCIRT, an alliance of the 5 top civil construction companies, undertook to fix all of the damaged infrastructure in Christchurch city from the February 2011 earthquake. Archival data involving all accidents, including near-misses, gathered since the post-earthquake rebuild began was accessed and reviewed. The archival data was recorded and filed using only accident data; as no personal information was obtained nor recorded. This accident-data-only approach was used extensively in papers that were discussed in the literature review, including Heinrich (1931), where only quantitative data from insurance claims was utilised. For this research, qualitative data was collected using questionnaires and semi-structured interviews to attempt to answer questions focussed on participants' opinions and details that the archival accident data could not show.

Surveys in the form of questionnaires were handed out to a participant sample of 100 personnel in the civil construction sector in Christchurch. Questionnaires comprised a combination of multi-choice and open-ended questions. This method helped establish how participants perceived the Safety Pyramid, and gathered data that complemented the archival accident data to provide information on the relevancy of the Safety

Pyramid in Christchurch's post-earthquake civil construction rebuild projects. 69 completed questionnaires were returned from a range of participants operating at all levels and roles in civil construction. All of the questionnaires were filled in on-site at weekly safety meetings. Semi-structured interviews were subsequently conducted with five selected civil construction personnel -a Project Manager; an Engineer; a Supervisor; a Foreman and a Labourer, using 5 questions that resulted from the themes and topics identified in the analysis of the questionnaire responses.

DATA FINDINGS AND ANALYSIS

Major Accidents	33
Minor Accidents	147
Near miss Incidents	654
Safety conversations	70,692

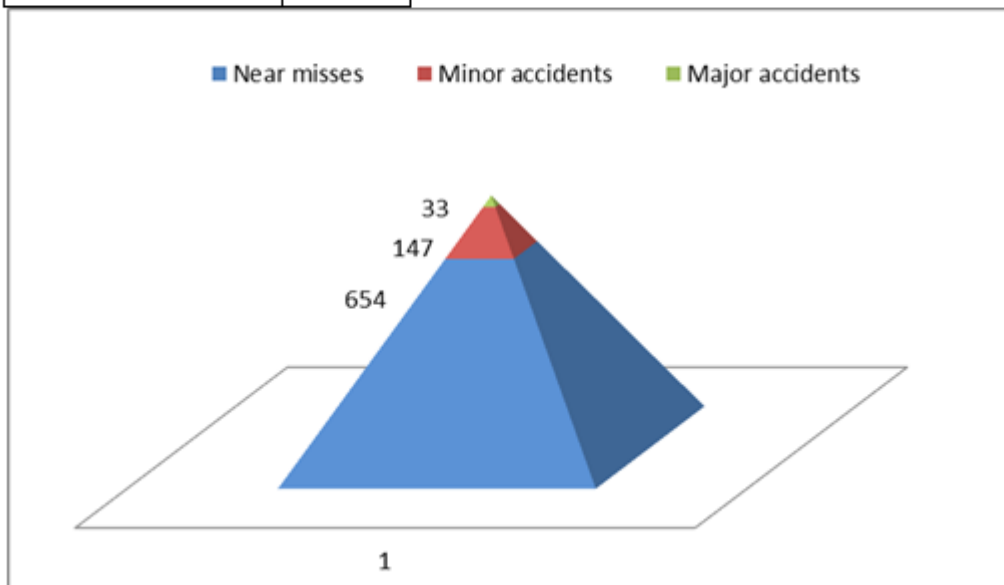


Figure 2 Christchurch's Civil Construction Rebuild Archival Accident Results for the year ending June 2013 (SCIRT).

Of note in reference to Figure 2 above, was that some of the companies involved in the SCIRT alliance recorded significantly less minor accidents, than others in the alliance. Overall though, the ratio for Christchurch's post-earthquake civil construction rebuild was 1-5-20, identified as one major accident to five minor accidents to twenty near miss incidents whereas Heinrich's ratio was 1-29-300. This demonstrates that there were significantly more major injuries in Christchurch's civil construction rebuild projects than when Heinrich (1931) first established that ratio.

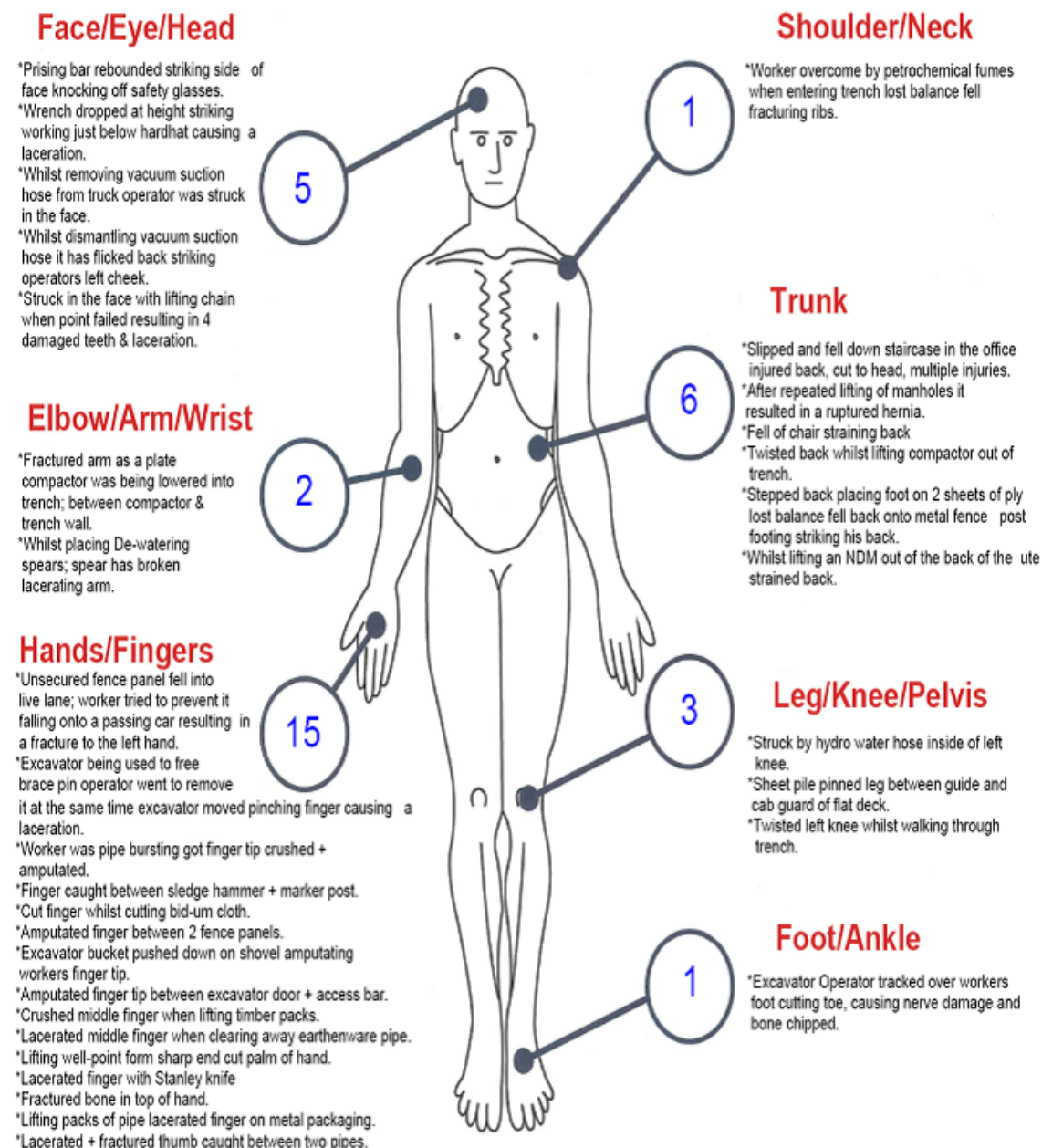


Figure 3 Civil Construction Post-Earthquake Christchurch Major Accidents.

Heinrich (1931) was using accident data from insurance claims that were gathered over a wide range of industries. It is not unusual that civil construction would realise a lower ratio, as construction has always been a sector with a high rate of accidents. However, as at June 2013 no fatalities had occurred in Christchurch's post-earthquake civil construction sector rebuild, and that some of the major injuries were just classed as minor injuries. A few of the more serious injuries such as finger amputations definitely fell into the 'major' category. Given that first-aid type injuries were not always recorded, this could have had an affect on the actual results. However, as noted by Heinrich(1931), only the recorded data can be used. Adding the 70,692 safety conversations to the Safety Pyramid may be of use to civil construction in Christchurch, but as a comparison to Heinrich's Pyramid it was not relevant, as no such data was collected on or around 1931. Heinrich's Pyramid referred to major, minor or no injuries, whereas results for this research were listed under major, minor or near-misses (the name also used for the no-injury' category). Smith (2006),

observed that *"there are advantages in measuring proactive statistics"* (data collected via interviews/market research surveys), *"rather than just reactive statistics"* (data collected/received once product/service used), *"even though proactive statistics are harder to compare."*

Table 1 Questionnaire Matrix Findings

Question 1. Do you recognise any of the safety pyramids shown below?	Yes 91% No 9%	A very good result with 91% recognising the pyramid which helped with the rest of the survey.
Question 2. Do you believe that you make use of the safety pyramid as part of your health and safety in your company?	Yes 53%, No 22%, Unsure 25%	Surprisingly only 53% say they use the Safety Pyramid. Most use it as a 'tool' to help explain 'safety' to others.
Question 3. Do you agree that reducing near misses will in turn reduce major accidents?	Strongly Agree 39%, Agree 53%, Unsure 4%, Disagree 3%, Strongly Disagree 1%.	Stopping accidents at their 'root cause' was a major theme. 'luck will run out' was another.
Question 4. Do you participate in near-miss reporting?	Always 58% Sometimes 39% Never 3%	97% do take part in near-miss recording, a good sign that the message of it's importance is getting through.
Question 5. Have you ever had or seen a near-miss and not recorded it?	Yes 39%, No 61%.	Unfortunately there can still be improvement in the amount of near-miss reporting as 39% do not do it enough.
Question 6. If yes, please explain the near-miss and why not recorded ?		Outside of work and a long time ago were common answers.
Question 7 Have you experienced a near- miss that could have been a major accident?	Yes 54%, No 46%.	Shows that there are a lot of times that a near-miss could have been a major accident of even a fatality.
Question 8. If you witnessed a large site- safety fence fall over from the wind but did not hit anything. Would you consider this a near-miss?	Yes 88%, No 12%.	Most agreed the scenario offered the opportunity to harm someone, so it was considered a near-miss.
Question 9. If an excavator bucket swung around and brushed against your clothing. Would you consider this a near-miss?	Yes 90%, No 10%.	Even more agreed that this was a near-miss with a few thinking that it was an incident.
Question 10. If you are not wearing the correct PPE for a task, for example, not having your safety glasses. Do you consider this a near-miss?	Yes 45%, No 55%.	Only half considered this a near-miss, as most explained there was no incident that took place.
Question 11. Do you agree that the target of zero-harm is achievable?	Strongly Agree 1%, Agree 25%, Unsure 22%, Disagree 45%, Strongly Disagree 7%.	Only 26% believed that zero- harm is achievable. Most however said we must try to achieve zero-harm.

The analysis of the 69 questionnaire response revealed that the majority of the companies' safety managers still use near-miss reporting and the Heinrich Safety Pyramid to aid their Health and Safety practises. However, near-miss reporting did not appear to accurately reflect the number of actual near-misses that occurred according to the participants. There were a range of reasons as to why these near-misses were not always reported, including being too busy on-site to fill out the paperwork, not wanting to get others in trouble with the boss for example. This might be one of the reasons why the SCIRT civil construction rebuild Safety Pyramid was dissimilar to Heinrich's (1931).

However, the majority of participants agreed that reporting near-misses, and working to reduce them will in turn reduce the more serious accidents. A few participants acknowledged using the Heinrich Safety Pyramid subconsciously despite not specifically setting out to.

Utilising potential scenarios in the questionnaire established that not all employees were aware of what actually defined a near-miss that should be reported. Respondents further identified other technicalities that might have meant that a situation/event changes from being a near-miss, into an incident report. The target of 'zero-harm' is still a long way off according to the majority of respondents, but a large percentage also agreed that this must be a target goal as anything less is unacceptable.

As illustrated in Table 2 below, zero-harm whilst being a target goal, is hard to achieve when there are continual changes amongst team members on-site, all with differing levels of safety awareness, despite standard safety inductions for all new staff. The supervisor for example, noted that *"once there are no accidents for a while, people start to become complacent and the chance of a serious accident increases"*.

A common response from the interviewed participants was that workers have differing views on what constitutes a near-miss. Many feel uncomfortable about reporting near-misses for fear of getting a workmate into trouble, or simply forget to report most near-misses, believing that only major near-miss accidents need to be reported.

Table 2 Interview Matrix Findings

	Project Manager	Engineer	Supervisor	Foreman	Labourer
Q1 Why do you think your company's personnel feel that zero harm is not achievable?	Human error	You have to allow for stupidity	We may get close but will never have zero	Dumb moments	There are always idiots, accidents happen
Q2 Why do you think some near-misses are not recorded on project sites that you are familiar with?	Misunderstanding of what a near-miss is	Getting someone into trouble	Too busy to do all the required paperwork	Forget a lot	Getting themselves or someone else into trouble
Q3 Do you feel that the way forward is concentrating on major accidents or near-miss injuries, and if why?	Major accidents	Combination of both	Both but more major accidents	Combination of both at same time	Major accidents
Q4 If you organise the induction for new staff, would you use the Safety Pyramid to illustrate near-miss reporting. If so why/why not?	Yes valuable tool	Yes easy to use	Yes and able to demonstrate visually	No. would use real life scenarios	Yes was clear to understand
Q5 Are your company definitions of near-miss reporting clear to staff? Please explain your definition of a near-miss.	Clear. Something that could have hurt you but did not	Clear. An accident that could have hurt someone	Clear. A situation that may have been an accident on another occasion	Unclear. Some people are a bit lazy	Unclear. New people unsure

There were positive responses from 4 of the participants that the Heinrich Safety Pyramid is a valuable visual graphical tool at the induction of new staff, as it is easily understood. The participants noted that the Safety Pyramid helps reinforce how serious near-misses actually are, and that it is frequently under-used. There was also agreement amongst the majority of the selected interview participants that the way forward involves a concentration on reducing both major and minor accidents. There was also agreement that all near-miss accidents need to be reported, going forward, in order to reduce major accidents, and the overall number of on-site civil construction accidents in Christchurch. This was a useful result given the focus of the research being to establish how relevant Heinrich's Safety Pyramid is to Christchurch's post earthquake civil construction rebuild health and safety practises.

CONCLUSIONS

The objectives of the research were to establish the continued relevancy of Heinrich's Safety Pyramid to safety practices on Christchurch's post-earthquake civil construction sector rebuild projects, and to identify whether the near-misses recorded were an accurate reflection of what was actually happening on-site. The relevancy of the Safety Pyramid results were divided in the literature review findings, with approximately fifty percent supporting the pyramid, and fifty percent not supporting the original Heinrich's Safety Pyramid's use. The questionnaire results were mixed but revealed that the majority of the companies' safety managers still use near-miss reporting and the Heinrich Safety Pyramid to aid their Health and Safety practises. However, near-miss reporting did not appear to accurately reflect the number of actual near-misses that occurred according to the participants. There were a range of reasons as to why these near-misses were not always reported, including being too busy on-site to fill out the paperwork, or not wanting to get others in trouble with the boss for example. Four of the five selected interviewees believed that targeting both major and minor accidents and reporting all near-misses was equally important. The 69 /100 personnel surveyed demonstrated that a significant majority believed that the Safety Pyramid was relevant in today's health and safety practises in Christchurch's post-earthquake civil construction rebuild. There was significant support from those surveyed with the questionnaire, and those interviewed for the use of the Safety Pyramid as a tool to visually demonstrate how near-miss reporting can reduce major accidents by attending to the hazard before it results in an accident. Overall the findings positively supported the premise that Heinrich's Safety Pyramid continues to be relevant for safety practices on Christchurch's post-disaster civil construction rebuild projects.

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