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Common human factors underlying worker fatalities in the waste and recycling industry

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Improvement in health and safety performance in the waste sector is a priority for HSE. The waste management and recycling industry accounts for about 0.4% of employees in Great Britain. However, the fatal injury rate was fifteen times greater than the average across all industries over the period 2012/13 – 2016/17.

This report describes research to identify common underlying human factors that have contributed to fatal incidents within the waste and recycling industry. Eighteen fatal incidents were analysed: 12 in small and medium enterprises (with less than 250 employees) SMEs, and 6 in large enterprises. The research identified four top level human factors: (i) '*preconditions for deficit*' (ie fundamental issues) such as lack of separation of workers and hazardous machinery; (ii) '*organisational influences*' such as inadequate safety management systems and safety culture; (iii) '*individual actions*' such as tasks not being performed in the safest manner; and (iv) '*wider influences*' specific to SMEs such as machinery that is supplied to them with inadequate documentation on safe operation. The majority of factors were not specific to company size.

The research also identified potential actions to reduce the likelihood of future fatalities. These focus on: equipment selection, use and maintenance; raising awareness of associated risks; the need for effective safety management systems; and the sharing of good practice. These potential actions are irrespective of organisational size.

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Common human factors underlying worker fatalities in the waste and recycling industry

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KEY MESSAGES

The GB waste and recycling industry has a high rate of worker fatalities. This rate was fifteen times the average rate across all industries for the period 2012/13 – 2016/17. Human factors issues within the industry are a contributory cause.

Research was carried out to identify common human factors underlying fatal incidents and to provide insights into possible options for concerted action to help reduce the likelihood of serious incidents or fatalities. The research reviewed 18 fatal incidents and included in-depth interviews with HSE inspectors involved in the incident investigations. Of these incidents, 12 were in 'small and medium enterprises', SMEs (with less than 250 employees) and 6 in large enterprises (250 or more).

The research identified four interrelated key human factors issues:

1. **Fundamental issues - 'Preconditions for a deficit'.** These issues relate to: the work environment, specifically the lack of separation between people and the hazardous machinery on sites; equipment that does not appear to be fit for purpose; the equipment's design and/or lack of maintenance; and poor practice in how machines are used. This is broadly consistent for SMEs and large enterprises. However SMEs appear to have more of an issue with maintenance.
2. **Organisational influences.** Generally, safety management systems were found to be inadequate and there were suggestions of poor safety culture in two thirds of cases. This is broadly consistent for SMEs and large enterprises. However, SME's appear to have more of an issue identifying control measures and there is some indication SMEs may have a worse safety culture.
3. **Individual action – 'Performance Deficit'.** Knowledge based errors appear to be the most significant as a result of individuals not having the necessary knowledge to perform or plan a task in the safest manner. There are examples of deliberate actions on site – routine or situational but there are other influencing factors potentially affecting their occurrence. There are also issues as the result of failures of machinery and/or materials. Issues related to knowledge based errors and deliberate actions were broadly consistent for SMEs and large enterprises. However there are slightly more occurrences of failures of machinery and/or materials in SMEs.
4. **Wider influences were identified that related solely to SMEs.** Some machinery was supplied with inadequate documentation, which meant the purchaser did not understand how to operate it correctly. In a small number of fatal incidents, external consultants provided inadequate risk assessments making an incident more likely to happen because inadequate controls were put in place.

The research identified two priority human factors areas to tackle to reduce worker fatalities: equipment factors including design, use and maintenance; and safety management systems. For example, whilst it is foreseeable that some organisations (both SMEs and large) may think their SMS is adequate and well documented the analysis indicated this was not always the case.

The research also identified potential options for solutions to tackle these human factors issues. These options are intended to act as discussion points between the regulator and industry to inform decisions on what will work in practice and what can be adapted to work within industry. The options focus on: equipment selection, use and maintenance in the industry; and raising awareness of the risks associated with equipment and the legal requirements for equipment use and maintenance. Related to this is the need for effective safety management systems and the sharing of good practice.

EXECUTIVE SUMMARY

Background

The waste management and recycling industry accounts for about 0.4% of the employees in Great Britain. However, the fatal injury rate for workers is over three times greater than in the construction industry (6% of employees) and fifteen times greater than the average rate across all industries over the five year period 2012/13 – 2016/17. An improvement in overall health and safety performance in the expanding waste and recycling industry is a priority for HSE. Collaboratively, HSE and industry stakeholders have developed a strategy with an aim of achieving zero deaths in the industry.

Aim

The aim of the research described in this report was to:

- identify common underlying human factors that have contributed to worker fatalities within the waste and recycling industry; and
- provide insights into possible options for concerted action to help reduce the likelihood of serious incidents or fatalities.

Method

This research sampled eighteen of the fifty-eight incidents in which workers were killed between 2008/09 – 2013/14 in the waste and recycling industry. Of the organisations involved in the incidents, twelve were classified as 'small and medium enterprises', SMEs, (less than 249 employees) and six were classified as 'large enterprises' (250 or more employees). These incidents covered a range of workplace activities such as kerbside collection and collection and / or sorting of waste or recyclable material on a fixed site.

Semi-structured interviews were conducted with the HSE inspectors involved in investigating the incident. Interviews were conducted to build on the human factors identified by the HSE incident investigation, exploring the 'greyer' areas of reasoning and deduction, where no causal-effect link can be proven. Incidents were broken down using a 'why – because' method for each event / condition and each emerging factor was assigned a weight based on its impact to the fatal incident ensuing.

Results

The research identified four interrelated key human factors issues: (1) Fundamental issues - 'Preconditions for a deficit'; (2) Organisational influences; (3) Individual action – 'Performance Deficit'; and (4) Wider influences were identified that related solely to SMEs. These four issues are interrelated. For example, an individual worker might not have the knowledge to work safely with equipment (a 'performance deficit') and be working with equipment that is not fit for purpose (a 'precondition for a deficit') and which has been provided, by an employer, without proper assessment of risks and implementation of control measures (an 'organisational influence') . Details of these four key human factors issues are as follows:

Key Human Factors Issue (1) 'Preconditions for Deficit' (Fundamental)

- **Work environment** appears to be one of the most influential factors, more specifically, it appears that people and hazardous machinery are not being separated on all work sites, which in turn is having a strong influence on a fatal incident occurring.

- **Equipment** does not appear to be fit for purpose; the equipment's design and / or lack of maintenance is hindering safe operations on site, influencing the occurrence of fatal incidents.

- Where **equipment is suitable**, issues arise around how that machine is being used on the site; poor practice when using machinery can influence the potential for a fatal incident.

- Results by an **organisation's size** (SME or large) indicate that **the above is consistent for both** SMEs and large organisations, however, **SMEs appear to have more of an issue with maintenance, potentially affecting the operational ability of the machinery** being used compared to large organisations.

Key Human Factors Issues (2) Organisational Influences

- **Generally safety management was found to be inadequate** on most sites, as evidenced by few or no procedures or control measures available for the work that was being undertaken. This is potentially influenced by poor organisational cultures, a lack of competent knowledge about materials or machinery being used and / or an inability to accurately identify risks associated with the work being undertaken.

- **Suggestions of poor safety culture were found** in two thirds of cases, characterised by a combination of a deliberate disregard for safety and a lack of ownership and control of health and safety issues.

- Results by **organisational size** (SMEs vs large) indicate that the **above is consistent** for both SMEs and large organisations. **However, SMEs appear to have more of an issue identifying control measures** and there is some **indication that SMEs may have a worse safety culture** but the evidence shows that poor safety cultures do also exist in the large organisation sample.

Key Human Factors Issues (3) Performance Deficit

- **Knowledge based errors** appear to be the most frequent form of performance deficit on sites and are the result of individuals (employers and employees) not having the necessary knowledge to perform or plan a task in the safest manner.

- There are examples of deliberate actions on site; **routine, situational** or **risk taking behaviour** but there are other influencing factors potentially affecting the occurrence of such actions.

- Performance deficits can also be the result of **failures of machinery and / or materials** and may be the result of poor maintenance or improper knowledge on how to use the machine or material.

- Results by organisational size (SME vs large) indicate **no discerning** difference between the

number and influence of **knowledge based errors and deliberation actions** across SMEs or large organisations. However, there are **slightly more occurrences of failures in machinery and / or materials in SMEs** compared to large organisations.
Key Human Factors Issues (4) Wider Influences that Relate Solely to SMEs
• Some suppliers of machinery provide **inadequate documentation** with the machine, which in turn leads to a knowledge gap in the purchaser's understanding of correct operation. • In a small number of fatal incidents, **external consultants** provided inadequate assessments of the organisation's risks, making an incident more likely to happen because inadequate controls were put in place. • The **above key messages are solely in relation to SMEs** as only these were influenced by inadequate documentation or poor advice from external consultants. • It is possible that the 'wider influences' factor impacts other factors rather than directly influencing the occurrence of a fatal incident.

The research identified two priority human factors areas to tackle to reduce worker fatalities and potential options for solutions to tackle these human factors issues. These options are intended to act as discussion points between the regulator and industry to inform decisions on what will work in practice and what can be adapted to work within industry. The areas and potential solutions are:

1) Equipment factors – these focus on equipment selection, use and maintenance. Organisations need to establish the intended use for the selected piece of equipment, whether this is right for the task, and ensure employees know how the machine should be used and maintained correctly. Potential solutions could be; the production by industry of guidance/information sheets for different types of equipment specifying the risks associated with the equipment and good practice in regards to use and maintenance. This could be particularly useful for SMEs purchasing second hand machinery with no supplied manuals. In addition, HSE and Industry could launch a joint communications campaign that focuses on raising awareness of an organisation's legal requirement to identify how equipment will be used on their site(s) and how it will be maintained.

2) Safety management systems, SMS – whilst it is foreseeable that some organisations (both SMEs and large) may think their SMS is adequate and well documented, the analysis indicated this was not always the case. By improving the SMS an organisation should be able to improve the separation of people and hazardous machinery, provide procedures on how and when work should be carried out and what equipment is required, and provide effective and enforced control measures on site. Introducing these changes is likely to limit the number of routine/deliberate unsafe acts, reducing the likelihood of incidents. This may have a strong impact for the small number of SMEs who purchase second hand machinery and are not provided with any documentation and/or rely on the sole advice of external consultants who may provide them with inadequate risk assessments.

In conclusion, these common human factors issues link to the need for better safety management with an emphasis on information and good practice for equipment used within the industry. There is a need for solutions that are effective for the industry as a whole rather than specific to the size of organisation.

CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 Health and Safety in the Waste and Recycling Industry

The waste management and recycling industry accounts for about 0.4% of the employees in Great Britain. However, the fatal injury rate for workers is over three times greater than in the construction industry (6% of employees) and fifteen times greater than the average rate across all industries over the five year period 2012/13 – 2016/17 (1).

An improvement in overall health and safety performance in the expanding waste and recycling industry is a priority for HSE. This prioritisation is driven by: poor health and safety performance compared to other industries; high rates of worker fatalities, occupational health issues including musculoskeletal disorders, work related stress and occupational lung disease (2); and the direct and unavoidable public interface, especially in collection activities, together with fatalities to members of the public. Collaboratively, HSE and industry stakeholders developed a strategy with an aim of achieving zero deaths in the industry: 'Delivering the solution together: A strategy for the waste management and recycling industry (2012 - 2015)' (3).

1.1.2 The Role of Human Factors in Fatalities and Injuries

About 60-90% (4) of incidents (not specific to industry sector) are considered to be the result of human error. The human factors discipline examines the interaction between an individual and their workplace and encompasses three key aspects (5):

- Individual factors (e.g. risk perception, attitudes towards safety);
- Job factors (e.g. safety procedures, design of equipment); and
- Organisational influences (e.g. organisational culture, safety management) that can lead to human error.

Previous research by BOMEL published by HSE in 2004 (6) and by Nobel Denton BOMEL published by HSE in 2009 (7) analysed the incident data for the waste industry from the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, RIDDOR, reporting system (8) and recommended a deeper analysis of the incident scenarios to gain an understanding of the incident causes. The 2004 BOMEL report (6) also examined the perceived influences on health and safety within the waste and recycling industry by running two small workshops involving representatives from the private sector, industry associations and regulators. The workshop results indicated that there may be direct (e.g. competence, communications and compliance), organisational (e.g. training, procedures and supervision), policy (e.g. health and safety management) and environmental (e.g. regulator) influences on health and safety that impact the occurrence of incidents both during waste collection and waste landfill and treatment. Although this was only a small sample that resulted in expert judgement based conclusions, these topics highlight potential human factors issues within the waste industry.

Actions to improve health and safety performance within the waste and recycling industry are being driven from a number of evidence sources. (Examples of actions are given in references 9, 10, 11, 12, 13, 14 and the further links within these references.) In order that further actions to reduce worker fatalities can be informed by robust evidence on human factors issues, an in depth study was needed. This report describes research into common human factors causes of worker fatalities over the last five to ten years.

1.2 AIM

The aim of this research was to:

- identify common underlying human factors that have contributed to worker fatalities within the waste and recycling industry; and
- provide insights into possible options for concerted action to help reduce the likelihood of serious incidents or fatalities.

1.3 OBJECTIVES

The key objectives of the project were to:

1. Collate information on the previous five years (2008/09 – 2013/14) of fatal incidents in the waste and recycling industry;
2. Use a systematic approach to identify human factors aspects that have contributed to the incidents occurring;
3. Identify options for measures or approaches that could reduce the likelihood of similar incidents recurring;
4. Consolidate the findings from analysis of the incidents to identify the commonly occurring themes of causes and commonly occurring measures to prevent incident recurrence, and to draw up these insights for consideration by selected stakeholders;
5. Deliver findings in a way that suits the needs of HSE and the industry.

2 METHOD

2.1 SAMPLE

A random sample of eighteen out of fifty-eight fatal incidents between 2008/09 and 2013/14 were reviewed as part of this project. Three of the fatal incidents involved kerbside collection activities and fifteen involved the collection and / or sorting of waste / recyclable material on a fixed site.

The size of the companies varied with: five micro organisations (less than 10 employees); six small organisations (between 10 and 49 employees); one medium organisation (between 50 and 249); and six large organisations (more than 250). For this research organisations were classified as a 'small and medium enterprises' (SMEs) if they had 249 or less employees and 'large enterprises' if they had 250 or more employees. This allowed the researchers to identify any differences between the different sizes of organisations in the waste and recycling industry.

By having a randomly selected sample this research is not limited to reviewing fatal incidents for one particular activity or organisation and so takes a holistic view of the fatal incidents that have happened across the waste and recycling industry. By doing so, this research aims to provide points of consideration and potential solutions for the industry to improve health and safety performance as a whole.

Data was gathered through interviews with the HSE inspectors that had been involved in leading the investigation into each fatal incident and review of the investigation reports. A total of nineteen HSE inspectors were interviewed covering the eighteen fatal incident cases (one case had two inspectors).

2.2 PROCEDURE

An introductory letter was sent out to the HSE managers of all relevant/selected HSE inspectors informing them about this research and requesting that they provide inspectors with sufficient time to take part in this research. Inspectors were contacted individually by members of the research team, inviting them to take part, explaining the work and arranging a suitable time to interview the Inspector.

In preparation for the interviews, the research team reviewed each of the investigation reports, including any additional supplementary documentation (i.e. specialist reports) to produce an Effects Causal Factors Analysis (ECFA) diagram (15) that shows the factors leading up to the fatal incident (7). Additional notes were taken, on these diagrams, of any supplementary factors not included in the investigation report or accompanying documentation (e.g. more detailed explanations about the attitudes and behaviours towards safe working practices amongst employers and employees).

2.2.1 Reasons for the interviews and the analysis work providing additional information

Conducting interviews with the inspectors who investigated the incident required considerably more resources than examining only the documentation. To make sure this approach was justified, all incident causation factors (and related prevention measures) that arose specifically from the interviews were recorded. The main reasons why interviews might reveal useful information that is not in the incident case documentation are:

a) HSE investigations can be aimed at determining whether there have been breaches of legislation and regulations (e.g. Health and Safety at Work Act 1974 (HSWA)). As part of this process HSE

inspectors may investigate and identify any potential human factors for an incident. Interviews were conducted to understand these factors, exploring the 'greyer' areas of reasoning and deduction. These 'greyer' areas tend to be of importance to the human factors aspects because although a cause-effect link with the incident cannot be proved, the evidence can show the likelihood of the incident was increased. Examining these greyer areas can be important, especially when they appear in a number of incidents.

b) Most of the incidents involve a complex web of causal / influencing factors and the interviews provided important feedback on how these interlinked, which can be difficult to put into the narrative format of investigation reports (the original investigations rarely used ECFA charts to show the interlinking relationships). The interviews also brought about more insight into the influence of various factors, which was not available from the documentation.

c) Control measures described in the incident documentation were designed to deal with the specific circumstances of the incident within the specific organisation involved. The purpose of this research was to consider broader measures to prevent similar incidents across the wider waste and recycling industry, and the interviews provided the opportunity to discuss these.

d) In several cases, no measures were suggested in the incident reports because the company ceased all operations following the fatality. There were, however, lessons that could be learnt about measures to prevent related incidents, which could be discussed at interview.

2.3 ANALYSIS

2.3.1 Classification and coding system

A classification system was adopted from HSE's prior work looking at human factors issues in fatal incidents in the construction industry (16). Using this system allowed for a consistent and accurate analysis of investigation reports and interview data. It should be noted that the system was modified and expanded, forming additional categories to code for human factors related issues that relate specifically to the waste and recycling industry. Due to the complexity of the classification structure and the related alpha-numeric coding, a computer-based system was created to enhance the speed and accuracy of classifying the causes of the incidents reviewed.

The coding system enabled all of the incidents to be examined for the frequency and impact of the various causal factors. Collating the findings from all eighteen cases provided information that could be used in determining which causal factors might be targeted with interventions to reduce the probability of them contributing to further fatal incidents.

2.3.2 Concurrent analysis of the results

The causal and contributory factors found from the documentation and interviews were arranged in a series of 'Why – Because' links, as illustrated in Figure 1, to produce the chain of events and conditions leading to a fatal incident.

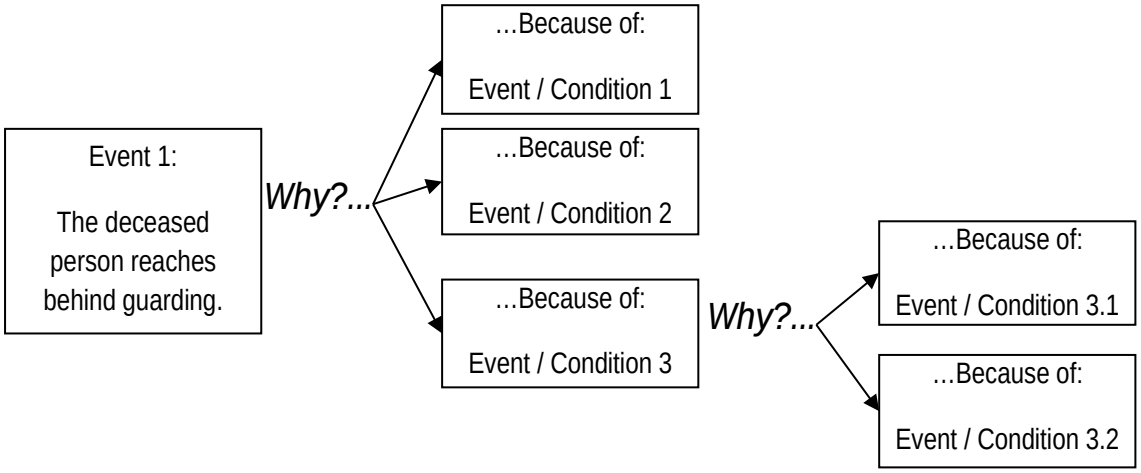

Figure 1: 'Why – Because' chain of events and conditions

A system for the concurrent analysis of the coding was set up using an Excel spreadsheet. This spreadsheet used the above method to break down the fatal incident. Each event / condition was coded using the classification system, giving immediate feedback on emerging results as the incident causes are entered. The spreadsheet allowed for an on-going, rolling review of the results of the fatal incident case analyses. The rolling review meant that analysis could cease when no new themes were emerging (as opposed to setting an overall target number of interviews to be completed).

Furthermore, as part of the analysis process, each time a theme was coded a weighting was also assigned to that theme. This weighting was scored on a scale of '0 to 3' with '0' having no influence on the ensuing incident and '3' having a high level of influence to the incident resulting. By weighting the emerging themes priorities can be identified about what HSE and the industry should target first.

3 RESULTS

3.1 INFLUENCING FACTORS

Four top level factors were identified as contributing to fatal incidents occurring in the waste and recycling industry; 'preconditions for deficit' (fundamental factors), 'organisational influences', 'performance deficit' and 'wider influences'. See Table 2 for definitions.

Category	Description
Preconditions for deficit	In most cases there were conditions and circumstances that set the scene for an incident. These preconditions could be the result of; an individual's attitude, knowledge or skills, job factors such as time pressures, environmental factors such as how a work area is laid out, the design of the equipment in terms of its practicality for its intended use and / or items of equipment may not be satisfactorily maintained.
Organisational influences	In most cases there were weaknesses in organisational processes and safety systems which can lead to an incident. For example, an organisation's inability to identify hazards and assess risks to determine appropriate control measures , leads to inadequate or no procedures / control measures being made available. This means an individual has no frame of reference to complete a task they may have been given, making a performance deficit more likely.
Performance deficit	In nearly all cases an incident happened because something or somebody failed to perform to the standard that was needed in order to prevent the incident from happening. In the case of a person, the performance deficit might be an error (unintentional action) or violation (deliberate action) that either contributed to, or directly resulted in, the incident. In the case of a material or object, the performance deficit might be a piece of machinery that fails or a piece of material not acting as intended.
Wider influences	The performance of organisational systems and the organisational culture can often be affected by external factors, such as the failings of suppliers, consultants and other organisations that the primary organisation has to deal with. There can also be influences from, for example, public opinions, regulators and economic / market influences.

Table 2: Definitions for top-level causal factors.

To understand how these factors contributed to a fatal incident occurring, each factor was broken down to establish the frequency and level of influence each had (see Figure 2).

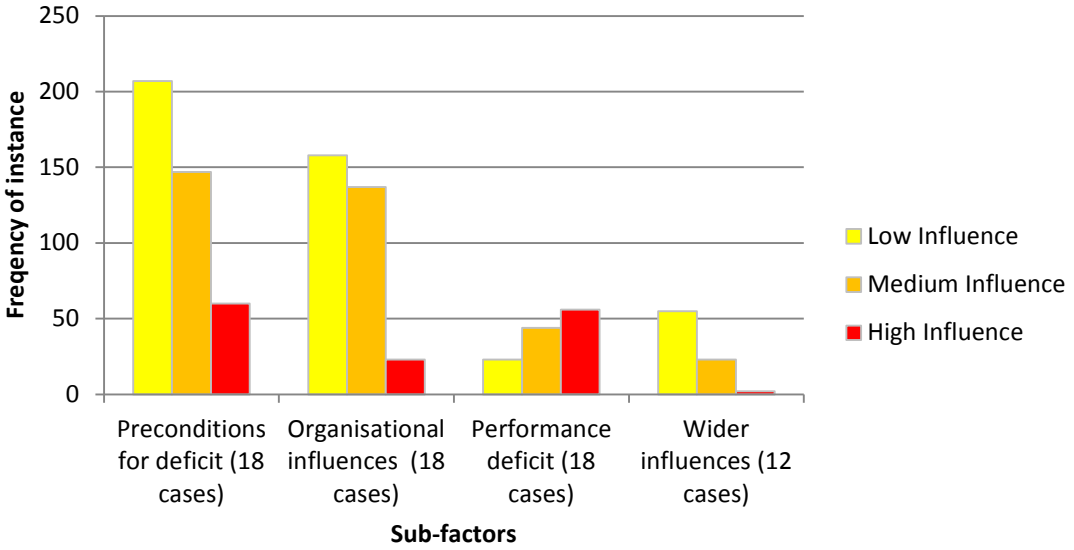

Figure 2: Influence levels for each of the factors contributing to incidents in the waste industry

The results from Figure 2 indicate that the most prevalent factor was the 'preconditions for deficit', however, in terms of influence, both 'preconditions for deficit' and 'performance deficit' had high levels of influence across the reviewed incidents. In order to understand these top level results, to prioritise key areas and provide potential solutions for the waste industry, these four categories were further scrutinised to understand their composition, influencing sub-factors and any differences between organisation size.

3.1.1 Preconditions for deficit

This factor refers to fundamental conditions and circumstances that set the scene that can ultimately lead to an incident. The 'preconditions for deficit' factor was the most prevalent in terms of frequency and was present in all eighteen incidents reviewed.

Figure 3 presents a breakdown of the 'preconditions for deficit' factor, offering further insight to the sub-factors that contribute to this factor, highlighting the level of impact each sub-factor had to a fatal incident ensuing. A more detailed description of each sub-factor can be found below.

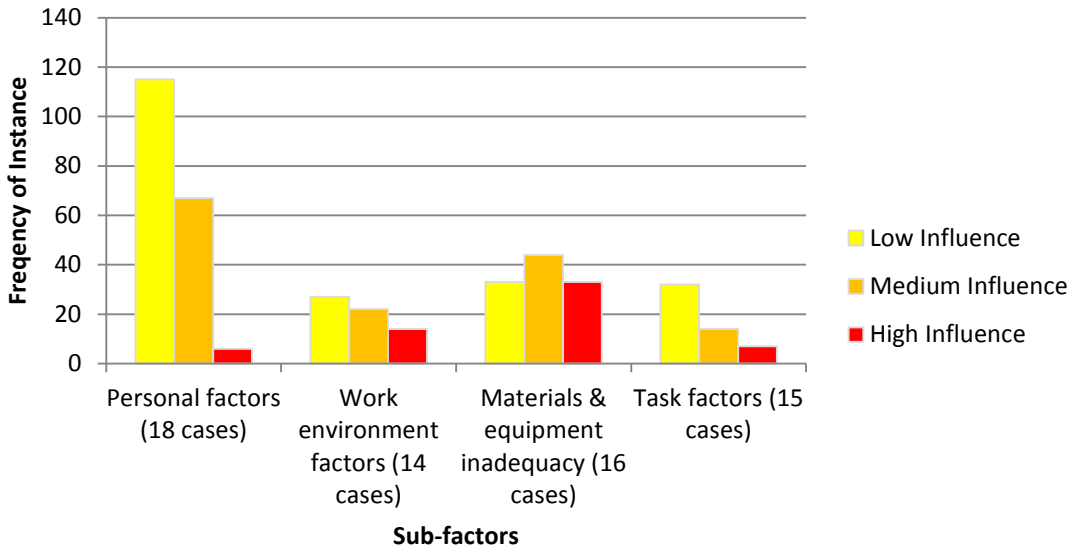

Figure 3: Influence levels for each of the sub-factors contributing to 'pre-conditions for deficit'

Personal Factors (18 of 18 cases)

Personal factors appear to be the most common form of 'preconditions for deficit' (appearing in all eighteen cases) and further analysis indicated that this comprised of two main elements:

1) An individual's attitude, influenced by a lack of perception of the risk, complacency and / or overconfidence when presented with risks, and motivational incentives in terms of doing what the business and / or colleagues need them to do to get the job done.

2) An individual's training, competence and knowledge in regards to the task they were performing. This factor was further influenced by other extraneous influencers such as not being provided with any clear instructions for the work by the organisation or a lack of perceptual awareness of the individual to the risks presented to them.

Although personal factors contributed the most to the overall 'preconditions for deficit' factor, the high levels of influence this factor had in contributing to an incident was relatively low compared to the other sub-factors (see Figure 3). However, significantly poor risk perception had a strong influence in two of the cases reviewed and complacency and overconfidence each had a strong level of influence in two other cases.

Work environment factors (14 of 18 cases)

Work environment factors encompass the physical operating conditions employees experience at their respective site / place of work. Further analysis indicated that there appear to be issues with the work area layout being inadequate in terms of separating people and hazardous machinery effectively or that conditions in the work area were unstable and subject to deterioration, such as uncontrolled changes to the size of scraps piles. Noise, lighting and ground conditions were also seen as contributing to this sub-factor with noise levels impacting on communication and / or an

individual's perception of other less audible machinery moving into their immediate areas. Furthermore, it became apparent that there was an issue with the technological environment in terms of equipment operability / maintenance. The researchers decided that this topic required its own sub-factor to explore it in more depth and to separate the physical operating conditions already highlighted from equipment issues (see, Material and equipment inadequacy below).

Work and environment factors appear to have a high level of influence on whether an incident is likely to happen (see Figure 3). Although not as frequent as 'personal factors', nine of the eighteen cases reviewed highlighted the proximity of people and hazardous machinery as an issue and in six of these cases this was a strong level of influence leading to the incident.

Materials & equipment inadequacy (16 of 18 cases)

The design of equipment and how it is used appear to have an influence on an incident occurring. For example, the review highlighted incidents where the design of the machinery made the fatal incident more likely to happen because of unclear control functions; conveyors becoming unstable or not being able to cope with the quantity of waste material leading to blockages; and restricted vision when operating specific types of plant. Furthermore, the performance of machinery and materials appears to be impacted by an individual not using the machinery in the intended manner, either due to ignoring safe working practices and / or a lack of risk identification as to how the machine should be operated. Additionally, where machinery has been used in the correct manner, inadequate or a lack of maintenance appears to impact the likelihood of a machine failing.

Similar to 'work environment factors' (see above) 'Materials and equipment inadequacies' was not the most prevalent sub-factor but had the highest levels of influence to the overall 'pre-conditions for deficit' factor (see Figure 3). More specifically, the design, use and affordance of a piece of machinery had strong levels of influence in five of the sixteen cases. How the equipment was being operated, the reliability of the equipment and the maintenance of the equipment also contributed to the high levels of influence in three and two of the sixteen cases, respectively.

Task Factors (15 of 18 cases)

The task an individual had been required to carry out has an impact on an incident occurring, for example being required to unblock a conveyer system or to clean / maintain a specific area of the site. Whilst at face value this may seem understandable, there appears to be other influential task factors such as incentives to work quickly or time pressures because of running behind schedule.

Figure 3 demonstrates that the level of influence that task factors had on incident potential, however this was not as strong as some of the other factors.

Influence of 'preconditions for deficit' sub-factors

Reviewing the levels of influence each sub-factor had on the primary factor (see Figure 3), it appears that the strongest influencers to a fatal incident come from 'materials & equipment inadequacy' and

'work environment factors' sub-factors. More specifically, the machinery being used appears to not be fit for its intended purpose. This may be the result of a design oversight or that an individual / organisation operates the machine in a way that it was not designed for, or does not adequately maintain the machinery, which affects its operational ability. Furthermore, it appears that the proximity of people and hazards is not well planned, with individuals and machinery coming into regular contact.

Although 'personal factors' such as an individual's attitudes and knowledge (for the task and / or machinery they are completing / using) may be frequent in most fatal incidents, they alone are not the primary influence of such incidents ensuing. However, 'personal factors' should not be discarded as they usually interact and influence other factors increasing the possibility of a fatal incident. For example, having poor knowledge about how to complete a task may make an 'error' more probable, but it is the 'error' factor that is recorded as having the most influence on a fatal incident because it is the most immediate cause of the incident.

Although task factors (e.g. an individual required to unblock a conveyor) offer some strong influences on a fatal incident happening, it is probable that this alone would not explain why an individual was performing the task. There could be other contributory factors such as a lack of safety management (i.e. no prescribed instructions), personal factors in terms of individuals' attitudes towards risks, incentives to work quickly or inadequate time allocations for work.

Differences within the 'preconditions for deficit' sub-factors by organisation size

Results were examined to identify any differences in the strong influencing sub-factors (materials & equipment inadequacy & work environment factors) between SMEs (less than 249 employees) and large (more than 250 employees) organisations.

Results for SMEs and large organisations indicated high levels of influence for a fatal incident occurring from both; 'materials & equipment inadequacy' and 'work environment factors' sub-factors. Furthermore it would appear that the issue regarding the 'proximity of people and hazardous machinery' is prevalent in both SME's and large organisations.

However, there are some differences between SMEs and large organisations in regards to equipment inadequacies. Evidence from both sizes of organisation highlight issues with equipment design, usability and poor practice when using equipment. However, what does stand out is that for SMEs the equipment being used is poorly maintained, which in turn may be affecting its operational ability.

Key Human Factors Issue (1) 'Preconditions for Deficit' (Fundamental)

- **Work environment** appears to be one of the most influential factors, more specifically, it appears that people and hazardous machinery are not being separated on all work sites, which in turn is having a strong influence on a fatal incident occurring.
- **Equipment** does not appear to be fit for purpose; the equipment's design and / or lack of maintenance is hindering safe operations on site, influencing the occurrence of fatal incidents.
- Where **equipment is suitable**, issues arise around how that machine is being used on the site; poor practice when using machinery can influence the potential for a fatal incident.
- Results by an **organisation's size** (SME or large) indicate that **the above is consistent for both** SMEs and large organisations, however, **SMEs appear to have more of an issue with maintenance, potentially affecting the operational ability of the machinery** being used compared to large organisations.

3.1.2 Organisational Influences

In all eighteen cases it became apparent that there were weaknesses in organisational processes and systems, which in turn set up the circumstances for preconditions and individual failures, which then led to a fatal incident.

Figure 4 presents a breakdown of the sub-factors that contribute to the overall 'organisational influences' factor, highlighting their frequency of occurrence and the level of influence each sub-factor had on a fatal incident ensuing. A more detailed description of each sub-factor can be found below.

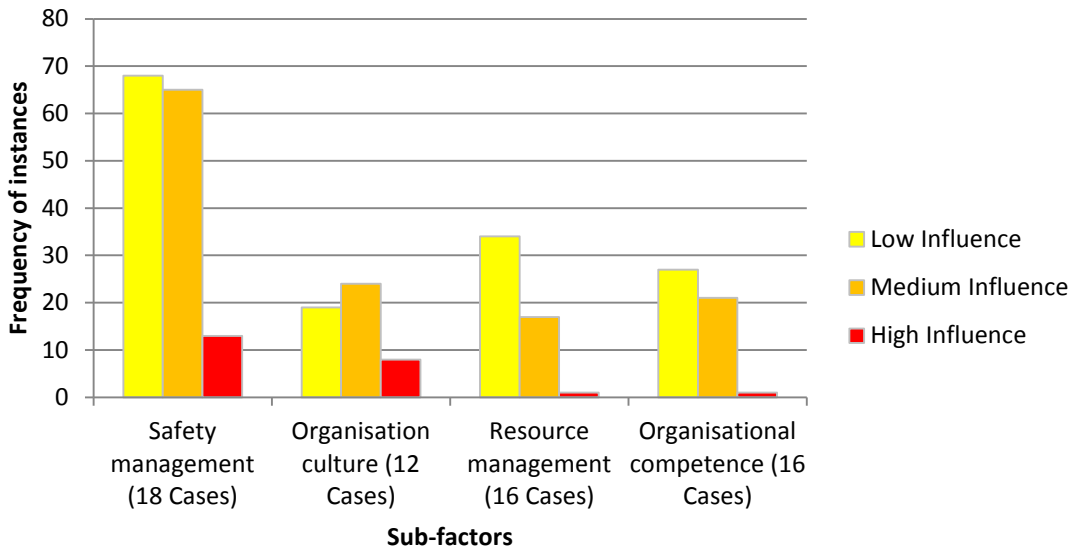

Figure 4: Influence levels for each of the sub-factors contributing 'organisational influences' factor

Safety management (18 of 18 cases)

It appears that there were poor or inadequate SMS in place across all of the eighteen cases reviewed. Notably this was characterised by inadequate or no procedures available to employees, lack of effective supervision, inadequate or no risk assessments and control measures not being identified or not implemented effectively to reduce the risk to employees.

Examining the data for influencing elements of this factor it appears that having no procedures had a high level of influence for the incident happening in three of the cases, with control measures not being implemented or identified also having high levels of influence in two cases each.

Organisational culture (12 of 18 cases)

For two thirds of the fatal incidents there was a suggestion of poor safety culture in organisations, characterised by a combination of a deliberate disregard for safety and a lack of ownership and control of health and safety issues.

All three of these elements contributed equally to the high levels of influence on a fatal incident ensuing in this sub-factor

Resource management (16 of 18 cases)

It was apparent that some organisations did not have any policies or resources set aside to inspect or maintain equipment, furthermore training was not recognised as being required for employees or, where given, the quality of training provided was poor.

The number of high influencing elements in this sub-factor was very low with only inadequate training from one case being highlighted as having a high level of influence on an incident occurring.

Organisational competence (16 of 18 cases)

An organisation's competence in this report refers to the competence of the employer. What was apparent was a lack of technical knowledge (i.e. knowledge about the machine / material they were operating with) amongst employers and employees in half of the cases reviewed and an inability to competently identify hazards and assess and control risks on a site (in almost two thirds of cases).

Exploring the number of high influencing elements within this sub-factor, both poor technical knowledge and poor competency with risk identification and control had high levels of influence in one case each.

Influence of 'organisational influences' sub-factors

It is perhaps unsurprising that 'safety management' had the highest levels of influence on a fatal incident ensuing when the other sub-factors are taken into account. For example, the poor safety culture and / or the lack of organisational (i.e. employer) competence in terms of risk identification is

likely to influence, and be influenced by, the poor / inadequate safety management. This may lead organisations to not provide adequate resources for maintenance of machines nor provide adequate training and / or procedures to their employees on how work should be done safely.

Consequently, although poor safety management may have the most influence in regards to the 'organisational influences' factor as coded for this research, tackling this issue is likely to require consideration of a wider range of issues. This will include helping organisations understand how and why an effective SMS is beneficial and not a hindrance to their work.

Differences within the 'organisational influences' sub-factors by organisation size

Results were examined to identify any differences in the strongest influencing sub-factors (safety management and organisational culture) between SMEs (less than 249 employees) and large (more than 250 employees) organisations.

The results indicate that both SMEs and large organisations have similar results regarding safety management as the overall result. Both have instances where no procedure has been specified for a piece of work and both have issue with implementing control measures. However, a slight difference is that SMEs appear to have more of an issue assessing risks and identifying control measures than larger organisations whose predominant issue is around the implementation of control measures.

Furthermore, in regards to organisational culture, the results suggest SMEs have a worse safety culture than large organisations. This is characterised by a higher proportion of responses indicating a deliberate disregard for safety and a lack of ownership and control of health and safety issues. However, this is not to say that a poor safety culture does not exist in large organisations, merely there are a higher proportion of instances in SMEs (*n.b.* a larger number of SMEs were included in the sample).

Key Human Factors Issues (2) Organisational Influences

- **Generally safety management was found to be inadequate** on most sites, as evidenced by few or no procedures or control measures available for the work that was being undertaken. This is potentially influenced by poor organisational cultures, a lack of competent knowledge about materials or machinery being used and / or an inability to accurately identify hazards and assess risks associated with the work being undertaken.

- **Suggestions of poor safety culture were found** in two thirds of cases, characterised by a combination of a deliberate disregard for safety and a lack of ownership and control of health and safety issues.

- Results by **organisational size** (SMEs vs large) indicate that the **above is consistent** for both SMEs and large organisations. **However, SMEs appear to have more of an issue identifying control measures** and there is some **indication that SMEs may have a worse safety culture** but the evidence shows that poor safety cultures do also exist in the large organisation sample.

3.1.3 Performance deficit

In almost all eighteen cases, a fatal incident happened because something or somebody failed to perform to the standard that was needed in order to be safe.

Figure 5 presents a breakdown of the sub-factors that contribute to the overall 'performance deficit' factor, highlighting their frequency of occurrence and the level of influence each sub-factor had to an incident ensuing. A more detailed description of each sub-factor can be found below.

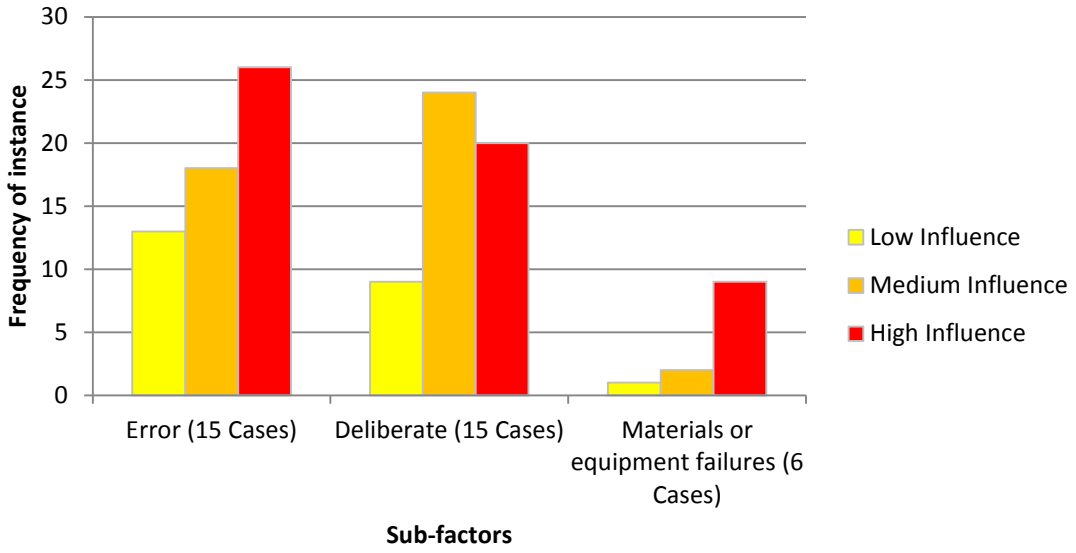

Figure 5: Influence levels for each of the sub-factors contributing 'performance deficit' factor

Error (15 of 18 cases)

Errors are classified as unintentional actions that bring about a result that was not expected or intended. In this review it is apparent that the majority of errors were the result of poor knowledge. This means that an individual (employer or employee) making the error has encountered a situation that can be classed as novel to them, there is no set plan on how to act in such a situation and thus they revert to trial and error, using their own knowledge to complete a task. Although not as frequent, slips (performing the wrong action with the right intention) and lapses (forgetting to do an action) also appear to have some influence on a fatal incident occurring. Furthermore, when analysing the data, it became apparent that errors may also be the result of perceptual failures by the individual, possibly due to distraction at the time of the incident, or the error was the result of cognitive overload where the individual had multiple demands placed on them.

In terms of influence it is knowledge based errors that appear to have the highest level of influence on an incident.

Deliberate (15 of 18 cases)

Unlike an error, a deliberate failure is intentional and requires the individual to consciously decide to behave in said manner. It became apparent that the most frequent forms of deliberate action were those that were routine in nature, for example, regularly climbing onto / into machinery to remove

blockages. Such actions, to an individual, would likely be perceived as just a necessary part of their job.

Situational actions also appeared to play a part in a performance deficit. These were actions that were the result of being presented with a specific situation such as passing close to a moving piece of machinery that is obstructing a walkway.

Besides actions that were routine or situational, there appeared to be risk taking behaviours that lead to a deficit. These were actions that clearly defeated a safe system that was in place, for example climbing over / reaching through rail guarding to get to a blockage.

It appears that the most influential deliberate actions were routine or the result of risk taking behaviours.

Materials or equipment failures (6 of 18 cases)

What became apparent during the analysis was that a performance deficit was not always the result of an individual's actions alone but also the failure of materials / machinery. Such failures could be categorised as the machinery / materials not performing as intended, be this due to improper use or lack of maintenance of the machine.

The most influential factor in this instance was a failure of the equipment, which was apparent in four of the cases but material failure also had high levels of influence for two of the cases reviewed.

Influence of 'performance deficit' sub-factors

The results indicate that the most influential performance deficits were either knowledge based 'errors' or 'deliberate' routine and / or risk-taking actions taken by individuals.

A knowledge based error refers to an individual (employer or employee) not having the correct knowledge. This may be knowledge of how a task should be completed, the potential safety risks of the task or how a piece of machinery should be correctly operated. Such a deficit may be influenced by an inadequate SMS (as already highlighted) or due to an individual's bias, that is they think they know what they are doing and do not need guidance.

Where an individual may have sufficient knowledge but choses to violate prescribed rules, these violations may be routine (e.g. they / others have always done it that way), situational (e.g. supervisor not on site) or exceptional (e.g. person acts in manner for unforeseen reasons). However, such behavioural patterns are influenced by other contributory factors, such as, individual (e.g. personal attitude), organisational (e.g. organisational attitude to safety management) and job (e.g. the equipment's design) factors, which can lead to the risk-taking behaviour observed.

Additionally, there are high levels of influence for materials or equipment failures. What is apparent is that such failures do not just happen and are the result of other factors such as poor maintenance and poor knowledge on how to use the machine or material.

Differences within the 'performance deficit' sub-factors by organisation size

Results were examined to identify any differences in the three highly influential sub-factors and organisational size; SME (less than 249 employees) or large (more than 250 employees).

The results indicate both SMEs and large organisations have a similar frequency and influence levels for both knowledge based errors and deliberate actions, with no discerning pattern between either size of organisation. However, in regards to the failure of equipment and or materials, there are slightly more occurrences of this type of deficit in SMEs compared to large organisations (*n.b.* some such failures were also recorded in large organisations).

Key Human Factors Issues (3) Performance Deficit
• **Knowledge based errors** appear to be the most frequent form of performance deficit on sites and are the result of individuals (employers and employees) not having the necessary knowledge to perform or plan a task in the safest manner. • There are examples of deliberate actions on site; **routine, situational** or **risk taking behaviour** but there are other influencing factors potentially affecting the occurrence of such actions. • Performance deficits can also be the result of **failures of machinery and / or materials** and may be the result of poor maintenance or improper knowledge on how to use the machine or material. • Results by organisational size (SME vs large) indicate **no discerning** difference between the number and influence of **knowledge based errors and deliberation actions** across SMEs or large organisations. However, there are **slightly more occurrences of failures in machinery and / or materials in SMEs** compared to large organisations.

3.1.4 Wider influences

In twelve of the eighteen cases there were other factors external to the organisation that influenced the possibility of a fatal incident occurring.

Figure 6 presents a breakdown of the sub-factors that contribute to the overall 'wider influences' factor, highlighting their frequency of occurrence and the level of influence each sub-factor had on a fatal incident ensuing. A more detailed description of each sub-factor can be found in below.

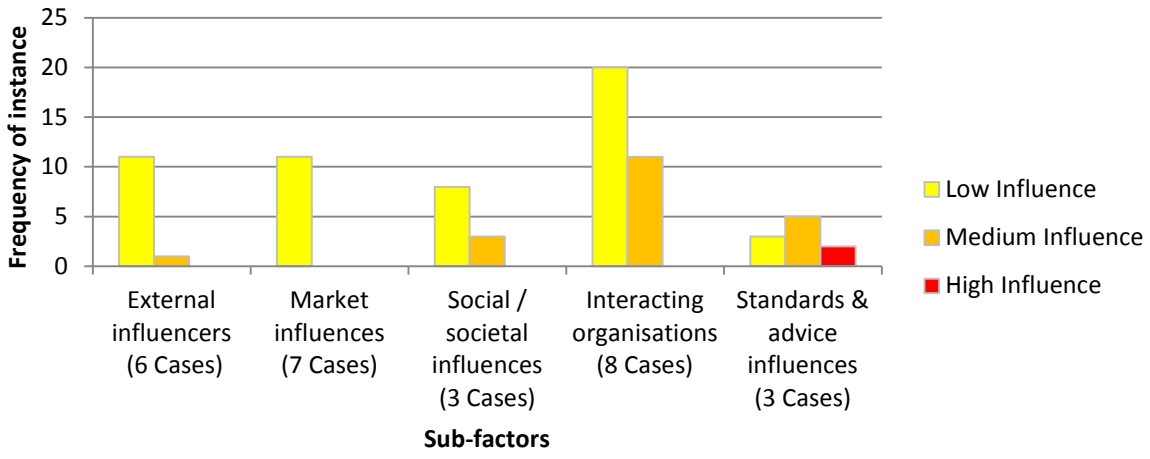

Figure 6: Influence levels for each of the sub-factors contributing 'wider influences' factor

External influencers (6 of 18 cases)

There were cases where operating restrictions meant an organisation needed to work in a specific way, which influenced the occurrence of an incident. For example, restrictions imposed by the local authority or environmental regulators (i.e. Environment Agency, Scottish Environment Protection Agency or Natural Resources Wales), in terms of operating hours and site boundary limits, can result in a highly pressured working environment when trying to work within these constraints.

In terms of influence, this was relatively low. Such operational restrictions alone do not necessarily make the incident more likely to happen, rather they will contribute to the influence of other factors (e.g. attitude and technical knowledge), which in turn can lead to an increase in an incident ensuing.

Marketing influences (7 of 18 cases)

The market appears to influence the occurrence of a fatal incident. This is in terms of the fluctuations within the market price of recyclable material, leading to organisations stockpiling recyclable material until the price is right to sell. This can lead to other issues such as the work area layout periodically changing, which could also invalidate any previously drawn up procedures / methods of work.

Although not as influential as some of the other sub-factors it is likely that this sub-factor increases the chance of an incident when combined with other factors, leading to a precondition for a deficit.

Social / societal influences (3 of 18 cases)

Primarily this sub-factor encompassed the influence of public attitudes and actions on an organisation which attributed to an incident occurring. For example, complaints about noise and pollution meant the organisation would either have restrictions placed on it by local authorities

and/or environmental regulators or try to be a good neighbour and adapt the design of their sites or how they operated.

In terms of influence, overall the impact was minimal in terms of the wider influences and was really limited to specific cases where complaints had been made by members of the public and subsequent changes or restrictions to the sites had been imposed.

Interacting organisations (8 of 18 cases)

The most common 'wider influence' sub-factor was the issue surrounding interacting organisations. This sub-factor primarily comprised of two themes:

1) That contractees were putting pressure on the organisation in terms of requiring a certain quantity and / or quality of output, which in turn was influencing how an organisation was operating to get the job done.

2) Suppliers of equipment did not appear to provide any, or little, safety related information about the machine an organisation was buying; this might include how to install or maintain a machine.

Although the most common in terms of frequency, the factor 'interacting organisations' did not have any instances of high influence leading to a fatal incident. It is likely this factor links with other factors, such as organisational culture, which has a much stronger influence on a fatal incident occurring.

Standards & advice influences (3 of 18 cases)

In a small number of cases, organisations had engaged a health and safety consultant to help them in identifying and managing the risks. This consultant subsequently provided poor or inadequate advice that did not address the risks, which ultimately led to the incident. In addition, there were a small number of instances where no advice was available to the organisation on how to install a piece of machinery because the manual was either not available from the re-seller or there were no guidelines available.

In terms of influence, this sub-factor had the highest level of influence (although not the most frequent) because poor advice impacted on how an organisation operated (i.e. not controlling risks). The organisation would defer to the risks highlighted by the consultant rather than identifying these themselves.

Influence of 'wider influences' sub-factors

It would seem that the most influential 'wider influences' are the lack of, or the inadequacy of, standards and advice provided to organisations in regards to safety management and correct equipment use. More specifically, in a small number of organisations, advice provided by an external consultant was not adequate and, in the case of purchasing of second-hand equipment, there were instances where no instructions for installation or use were provided. These factors could have

contributed to a knowledge based error occurring because individuals (employers or employees) either had incorrect knowledge or no knowledge on how a machine / task should be operated / completed safely.

Overall, the level of influence these sub-factors had was relatively low, although still important as such factors may have increased the likelihood of a fatal incident.

Differences within the 'wider influences' sub-factors by organisation size

Results were examined to identify any differences in the most influential sub factor (Standards & advice influences) between SMEs and large organisations.

The results indicate that it is solely SMEs that were influenced by the poor advice from consultants and / or the lack of adequate instructions / manuals in regards to purchasing second hand equipment.

Key Human Factors Issues (4) Wider Influences that Relate Solely to SMEs
• Some suppliers of machinery provide **inadequate documentation** with the machine, which in turn leads to a knowledge gap in the purchaser's understanding of correct operation. • In a small number of fatal incidents, **external consultants** provided inadequate assessments of the organisation's risks, making an incident more likely to happen because inadequate controls were put in place. • The **above key messages are solely in relation to SMEs** as only these were influenced by inadequate documentation or poor advice from external consultants. • It is possible that the 'wider influences' factor impacts other factors rather than directly influencing the occurrence of a fatal incident.

4 DISCUSSION

The results of the analysis echoed similar findings from previous research (3) in terms of influences from health and safety management, organisational influences and direct influences, such as competence. Whereas previous research distinguished between collection and landfill / treatment and was based on limited information, this research analysis is indicative of the industry as a whole. It provides an evidence based analysis of pertinent human factors issues associated with the causes of fatal incidents in the waste and recycling industry.

The research suggests that the key priority areas for HSE and the waste and recycling industry relate to the fundamental nature of the work environment and the proximity of operators to the hazards when performance deficits occur. These have the greatest influence on a fatal incident happening. Performance deficits are, however, usually the result of a combination of influencing factors and, like preconditions for deficits, it is important to ask "Why are people and hazardous machinery in close proximity to begin with?", "Do they have to be?", "Why do errors occur?" "What can be done to reduce the risk if an error does occur?"

HSE's guidance 'Risk assessment: A brief guide to controlling risks in the work place' explains that as part of evaluating risks, 'Ask yourself: Can I get rid of the hazard altogether? If not, how can I control the risks so that harm is unlikely?' (17). From a human factors perspective, risk controls would include removing the human contribution, for example by using an automated system. Questions include: Can the consequences of the human failure be prevented for example by putting additional barriers in place? Can the influences on performance be optimised (e.g. improve access to equipment, increase lighting, provide more time available for the task, improve supervision, revise procedures or address training needs)?

The following section uses the report findings, expert judgement and interpretation to identify priority human factors areas to address to help reduce the number of incidents in the waste and recycling industry. It sets out some potential solutions for consideration: these are to inform decisions on actions to move toward better practice.

When the results were examined by size of organisation (SME or large) some issues were found to occur more frequently in SMEs but they also existed in large organisations. Therefore, the information is provided for the industry as a whole but some areas are highlighted where SME's may need to give particular focus.

4.1 PRIORITY AREAS

4.1.1 Priority area 1: equipment factors

The first priority area is around the equipment being used in the waste and recycling industry. Equipment has a high level of influence on incident potential across both SMEs and large organisations and it appears the issues for equipment focus around its selection, use and maintenance. Specifically,

- design limitations in the equipment selected for use; and/ or
- equipment was not being used as intended by the manufacturer; and/ or
- inadequate or non-existent maintenance of machinery effecting its operational ability (more frequent in SMEs); and / or
- a lack of supplied instructions for second-hand machinery on correct installation, maintenance or usage of machines (primarily an issue for SMEs).

To address these issues organisations need to select equipment that is fit for purpose (the right equipment for the task) and ensure employees are aware of correct use and how the equipment should be maintained. It is probable that the issues relating to equipment are also influenced by the poor SMS because the risks associated with the selection, use and maintenance of the machinery is not sufficiently controlled. The lack of supplied information for second-hand machinery (pertinent for SMEs) could, possibly, be challenged by sharing safe practices relating to different equipment at industry level, thus filling any knowledge gaps due to lack of instructions.

By targeting equipment selection use and maintenance, organisations should start to identify any potential risks with machinery before they form a precondition for a deficit, potentially reducing the likelihood of any performance deficit occurring.

4.1.2 Priority area 2: safety management systems

A common re-occurring theme in the analysis indicated that all organisations had at least one issue with their SMS. For example,

- an inability to identify or adequately identify risks (primarily in SMEs but present in large organisations as well) from both employers and employees; and / or
- a lack of effective control measures (particularly for SMEs) or enforcement of control measures; and / or
- no plan, or an inadequate one, for how work was to be carried out.

A poor SMS can have wide influence on safety performance and is closely linked to safety culture. An effective SMS and improved safety culture will provide clarity about who is responsible for health and safety and reduce the number of deliberate unsafe actions, as both employers and employees understand the reasons for the good safety management.

By improving the SMS, an organisation should be able to identify the need to separate people and hazardous machinery, provide procedures on how and when work should be carried out (and what equipment is required), and provide effective and enforced control measures on site.

It is foreseeable that some organisations (both SME and large) may feel their SMS is adequate and well documented. However, the analysis indicated that even the more advanced SMS (typically found in larger organisations) although well documented, did not encompass how the work was actually being carried out by employees, possibly as a result of 'creeping changes'. (Creeping changes can be defined as the accumulation of small changes which often go unnoticed, but can add up to a significant change in a working environment or practices. Further information is provided in reference 18). Additionally, the SMS was not being enforced in some organisations making an incident more likely to happen.

4.1.3 Potential solutions

As part of the interviews, HSE inspectors offered potential solutions based on their experiences with the waste and recycling industry. This information was combined with good practice human factors advice and expert interpretation of the results, to suggest the following options.

- Have a joint HSE and Industry initiative such as a communications campaign (e.g. Safety Health and Awareness Days with industry), that would focus on raising awareness of an organisation's legal requirements (i.e. under the Provision and Use of Work Equipment Regulations (PUWER) 1998) to identify how equipment will be used on their site(s) and how it will be maintained.
    - For example, this initiative could get organisations, asking "Is this equipment the most suitable for the task?", "Is there a more suitable piece of equipment on the market?" Additionally, organisations could look to identify any issues with equipment (e.g. blockages, breakdowns etc.) asking "What measures can be taken to reduce blockages?"
    - A good place to start for maintenance could be the 'Maintenance system assessment: Guidance Document' (18). As part of this initiative, organisations should be reminded to involve staff to see how the equipment is used in practice, jointly producing a risk assessment and procedures that accurately reflect the use and maintenance of that piece of equipment.
- Have industry produce guidance/information sheets for different types of equipment, and specify good practice in using the equipment and identify the risks associated with that type of equipment, including any maintenance requirements. Such a resource may help where organisations buy second-hand equipment that has no instructions provided
- Share examples of effective management, particularly with SMEs. This might include the selection and appropriate use of equipment or how materials should be stacked safely.
- CCTV footage could be used to illustrate what poor safety management looks like (e.g. showing clips of dangerous use of machinery, risk taking behaviour etc.). This could help organisations and individuals identify hazards, assess risks, and identify appropriate measures to remove or control them.
- Any written documentation for workers about safe practice could include the use of images, wherever possible, to mitigate potential literacy and language barriers.
- Employee involvement in the development of safe processes and procedures can reduce errors and encourage them to behave safely; research shows that they feel more invested in the process and can appreciate the consequences of not following procedures.
- Training in risk awareness can help organisations understand the types of risks their industry face and how to reduce these risks, particularly the issue surrounding the lack of separation of people and hazardous machinery. Some courses already exist within the industry but, to be effective, the training needs part of an effective SMS; attendance is not sufficient to demonstrate competency.

- Industry initiatives should start at the management level because they are primarily responsible for managing the safety on sites, and it is this group that have the duty to keep their employees safe.
- There are recognised Environmental qualifications that a duty holder must obtain in order to operate a waste site: HSE and the EA could join together to ensure this qualification focuses not just on technical competence but also on good safety management.
- Having organisations set and commit to regular review points (e.g. annually) to assess the SMS. This is a requirement of the Management of Health & Safety at Work Regulations 1999 but the organisations need to ask, "Have there been any changes on site since the risk assessment was done or last reviewed?" For example, has there been a purchase of new machinery or any increases in production requirements?
- Provide training to organisations on how to train their employees to perform dynamic risk assessments for nonprocedural work. This training would include how to identify the potential risks and how these can be controlled (*note:* this would not replace risk assessments, but rather are advised as a supplement to encourage safe working practice by staff).
- Provide guidelines/information on what effective supervision looks like; work with industry using examples of good and poor practice for supervision. This could build on recent work by HSE researchers (20) which provides a starting point for competency development and training of supervisors and team leaders in the roadside waste and recycling collection.

Although evidence-based, the options for solutions offered above are not intended to be used prescriptively: rather they should act as discussion points between the regulator and industry to identify what will work in practice and what can be adapted to work within industry.

5 CONCLUSIONS

This research used an evidence based approach to review fatal incidents in the waste and recycling industry. Based on these findings, it can be concluded that the major common human factors issues that need to be addressed are as follows.

- **Equipment**. There is a need for better information for organisations to help them understand which equipment would be best suited for the task they are undertaking: improved understanding within the industry of what constitutes good practice with the use of equipment, and this good practice is adopted, and ensuring that the equipment itself is effectively maintained.
- **Safety Management.** There is a need for: better safety management; understanding what constitutes a risk; identifying hazards, assessing risks, and identifying effective control and mitigation measures; and controlling and effectively enforcing a safety system to reduce the risk to the workforce.

Whilst there are some differences between SMEs and large organisations, the majority of influential factors for a fatal incident are consistent across the two sizes of organisations. As such, solutions should be aimed at the industry as whole, irrespective of organisational size.

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Common human factors underlying worker fatalities in the waste and recycling industry

Improvement in health and safety performance in the waste sector is a priority for HSE. The waste management and recycling industry accounts for about 0.4% of employees in Great Britain. However, the fatal injury rate was fifteen times greater than the average across all industries over the period 2012/13 – 2016/17.

This report describes research to identify common underlying human factors that have contributed to fatal incidents within the waste and recycling industry. Eighteen fatal incidents were analysed: 12 in small and medium enterprises (with less than 250 employees) SMEs, and 6 in large enterprises. The research identified four top level human factors: (i) '*preconditions for deficit*' (ie fundamental issues) such as lack of separation of workers and hazardous machinery; (ii) '*organisational influences*' such as inadequate safety management systems and safety culture; (iii) '*individual actions*' such as tasks not being performed in the safest manner; and (iv) '*wider influences*' specific to SMEs such as machinery that is supplied to them with inadequate documentation on safe operation. The majority of factors were not specific to company size.

The research also identified potential actions to reduce the likelihood of future fatalities. These focus on: equipment selection, use and maintenance; raising awareness of associated risks; the need for effective safety management systems; and the sharing of good practice. These potential actions are irrespective of organisational size.

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