National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Learning from serious occupational accidents in the Netherlands

Developing a new monitoring system from 17 years of accident data

RIVM report 2021-0122

J. van Kampen | M. Lammers

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Synopsis

Learning from serious occupational accidents in the Netherlands
Developing a new monitoring system from 17 years of accident data

Accidents at work still happen regularly. These accidents have serious consequences for the victims, their family members, their colleagues and the companies and organisations where the accidents occur. The Ministry of Social Affairs and Employment (SZW), the Netherlands Labour Authority (NLA) and the National Institute for Public Health and the Environment (RIVM) are working together to learn from these accidents to help to prevent them.

For this purpose, data on serious accidents have been analysed and stored by the RIVM since 2003 using the so-called Storybuilder method. In 2018, the Ministry of Social Affairs and Employment decided to update this approach, which led to the development of the 'Monitoring System for Learning from Accidents' (MLfA). In this monitor, labour inspectors complete user-friendly questionnaires. As a result, RIVM researchers no longer have to manually analyse files with information about serious accidents.

In this report, RIVM explains why this questionnaire was created and how this was done based on historic data from the Storybuilder method. Since it was important for the new questionnaire to be user-friendly and reliable, RIVM collaborated on its development with experts and had the questionnaire tested by inspectors.

The questionnaire for the new monitor has been an integral part of the labour inspectors' work since 1 January 2020. In 2020, data were collected on 1,602 serious occupational accidents. More and more data will be collected in the years ahead. The lessons learned can be shared with the public through resources such as the www.lerenvoorveiligheid.nl website. The data will also be used by the labour inspectorate and, if needed, to develop policy.

Many different types of occupational accidents occur, and the way we work and implement safety at work is also changing. RIVM therefore recommends keeping the questionnaire up to date.

Keywords: occupational accidents, inspectorate, Ministry of Social Affairs and Employment, monitoring system, Storybuilder, questionnaire

Publiekssamenvatting

Leren van ernstige arbeidsongevallen in Nederland
Een nieuw monitoringsysteem op basis van 17 jaar aan ongevallen

Ongevallen op het werk komen nog regelmatig voor. Deze ongevallen hebben ernstige gevolgen voor de slachtoffers, hun familieleden, collega's en voor de bedrijven of organisaties waar de ongevallen gebeuren. Het ministerie van Sociale Zaken en Werkgelegenheid (SZW), de Nederlandse Arbeidsinspectie (NLA) en het Rijksinstituut voor Volksgezondheid en Milieu (RIVM) werken samen om van deze ongevallen te leren. Dat helpt om ze te voorkomen.

Voor dit doel worden sinds 2003 gegevens over ernstige ongevallen geanalyseerd en opgeslagen met de zogenoemde Storybuilder-methode. In 2018 besloot SZW om deze aanpak te vernieuwen, waarna de 'Monitor Leren van Ongevallen' is ontwikkeld. In deze monitor vullen arbeidsinspecteurs gebruiksvriendelijke vragenlijsten in. Hierdoor hoeven RIVM-onderzoekers niet meer handmatig dossiers met informatie over ernstige ongevallen te analyseren.

Het RIVM legt in dit rapport uit waarom deze vragenlijst is gemaakt, en hoe dat is gedaan op basis van historische gegevens uit de Storybuilder-methode. Het was belangrijk dat de nieuwe vragenlijst gebruikersvriendelijk en betrouwbaar is. Daarom heeft het RIVM hiervoor samengewerkt met experts, en hebben inspecteurs de vragenlijst getest.

De vragenlijst van de nieuwe monitor is sinds 1 januari 2020 een vast deel van het werk van de arbeidsinspecteurs. In 2020 zijn gegevens verzameld over 1.602 ernstige arbeidsongevallen. In de komende jaren worden steeds meer gegevens verzameld. De geleerde lessen kunnen worden gedeeld met het publiek, bijvoorbeeld via de website www.lerenvoorveiligheid.nl. De gegevens worden ook gebruikt door de arbeidsinspectie en om, zo nodig, beleid te ontwikkelen.

Er gebeuren veel verschillende soorten arbeidsongevallen en de manier waarop we (veilig) werken verandert ook. Het RIVM adviseert daarom de vragenlijst goed bij te houden.

Kernwoorden: arbeidsongevallen, inspectie, SZW, monitoringssysteem, Storybuilder, vragenlijst

Contents

Summary

Occupational accidents still occur regularly and can have serious consequences for the victims, their families and co-workers and for the workplaces where the accidents have occurred. In The Netherlands, if an occupational accident is serious, the organisation at which the accident happened is legally required to report it to the Netherlands Labour Authority (NLA). This inspectorate investigates both the accident and the workplace. In 2019 the NLA received approximately 4,500 reports and investigated approximately 2,200 occupational accidents that had serious consequences such as a permanent injury or hospitalisation. In 69 cases such accidents caused the death of the victim (Inspectie SZW, 2020).

The Dutch Ministry for Social Affairs, the NLA and the National Institute for Public Health and the Environment (RIVM) cooperate to draw lessons from these accident reports. This cooperation started around 2003 when the Ministry initiated a programme in which data on serious occupational accidents gathered by the NLA were systematically analysed by RIVM. For this purpose a 'bowtie' model was developed called Storybuilder (Sol et al., 2013). These data are still used, but since the end of 2014 new accident reports have no longer been added. More than 31,000 occupational accidents with more than 32,000 victims were analysed manually using Storybuilder.

Towards a user-friendly questionnaire
In 2018 it was decided that a new approach was needed and a Monitoring System for Learning from Accidents (MLfA) was developed. Reports would no longer be analysed by researchers; instead, it was decided to develop a questionnaire for use by the labour inspectors themselves.

In this report we detail how the MLfA was developed and show how it is related to Storybuilder. The MLfA can be seen as an evolution of Storybuilder that makes use of the foundation laid by many years of data-gathering and analysis, as well as on the modelling of occupational accidents. The questions in the MLfA were developed from the Storybuilder model and the data gathered over the years. Since the questionnaire was to be used by the inspectors themselves, user-friendliness and reliability were considered very important. No training should be required and inspectors should be able to use the questionnaire quickly and reliably, with questions that are relevant and clear and that they see as related to their daily work.

Questionnaire items were adapted from the existing Storybuilder models. Historical data were used to determine the questions that needed to be asked and the response options that should be included. The development team strove to develop questionnaire items that were factual rather than evaluative; short rather than long; explicit rather than implicit; and specific rather than generic. Some variables used in Storybuilder could not be easily adapted into a user-friendly questionnaire item and were therefore dropped.

Refinement, testing and implementation
The questionnaire items were refined through many iterative reviews and regular consultation with a group of domain experts. Pre-tests were conducted with inspectors, both in-person and online. These tests showed that the MLfA could systematically capture much of the complexity of occupational accidents.
The MLfA was put into active use on 1 January 2020 and has since become an integral part of the work of the labour inspectorate. It is used for all serious occupational accidents that are reported. Inspectors are required to complete the questionnaire when they close the file on a specific accident. For 2020, data on 1,602 serious occupational accidents was gathered. Chapter 4 includes examples of the type of information that is available in the MLfA.

Future directions
Data from the MLfA will be used to report on and monitor occupational accidents in the Netherlands and may in this way help prevent future accidents. The lessons learned can be shared with a wide audience in a similar way as is currently done with Storybuilder data (see for example the website www.lerenvoorveiligheid.nl). The data can also be used to help optimise the work of the labour inspectorate and to support policy making.

Occupational accidents are diverse and the way we work (and therefore what it entails to work safely) is constantly evolving. The complexity and diversity of occupational accidents and new hazards and risks make continual validation, maintenance and improvement of the MLfA necessary. RIVM recommends that the MLfA is continually and actively maintained.

Finally, with some adaptations the MLfA method may help (larger) companies, industry bodies and other intermediary organisations (nationally and internationally) to systematically gather, organise and learn from information on their own serious occupational accidents.

Samenvatting

Ongevallen op het werk komen nog regelmatig voor. Deze ongevallen hebben ernstige gevolgen voor de slachtoffers, hun familieleden, medewerkers en voor de bedrijven of organisaties waar het ongeval gebeurd. In Nederland is een bedrijf bij een ernstig arbeidsongeval verplicht dit te melden bij de Nederlandse Arbeidsinspectie (NLA). De arbeidsinspectie onderzoekt het ongeval en de werkplek. De arbeidsinspectie ontving in 2019 ongeveer 4.500 meldingen en onderzocht ongeveer 2.200 ernstige arbeidsongevallen die bijvoorbeeld tot blijvend letsel of ziekenhuisopname hebben geleid. Hiervan hebben er 69 tot de dood van het slachtoffer geleid (Inspectie SZW, 2020).

Het ministerie van Sociale Zaken en Werkgelegenheid (SZW), de Nederlandse Arbeidsinspectie (NLA) en het Rijksinstituut voor Volksgezondheid en Milieu (RIVM) werken samen om lering te trekken uit deze ernstige ongevallen. Deze samenwerking is rond 2003 begonnen, sindsdien worden de gegevens over ernstige arbeidsongevallen die verzameld worden door de arbeidsinspectie systematisch nader geanalyseerd door het RIVM.

Om de gegevens te analyseren is onder de noemer Storybuilder een systematisch ‘bowtie-model’ ontwikkeld. De gegevens in Storybuilder worden nog steeds gebruikt, maar nieuwe ongevallen worden niet meer toegevoegd; meer dan 31.000 arbeidsongevallen met meer dan 32.000 slachtoffers zijn handmatig geanalyseerd.

Van dossieranalyse naar een gebruikersvriendelijke vragenlijst
In 2018 is besloten dat er een nieuwe aanpak nodig is: er is een nieuwe Monitor Leren van Ongevallen ontwikkeld (afgekort de MLvO, of MLfA in het Engels in dit rapport). Dossiers hoeven met deze aanpak niet meer door RIVM-onderzoekers te worden geanalyseerd. In plaats daarvan is een vragenlijst ontwikkeld die direct door de inspecteurs zelf kan worden gebruikt. In dit rapport beschrijven we hoe de MLvO is ontwikkeld en laten we zien hoe deze zich verhoudt tot Storybuilder. De MLvO kan worden gezien als een ‘evolutie’ van Storybuilder die gebruikmaakt van een basis die is gelegd door jarenlang gegevens over arbeidsongevallen te verzamelen, te analyseren en te modelleren.

De vragen in de MLvO zijn ontwikkeld vanuit het Storybuilder-model en maken gebruik van de Storybuilder-modellen en de data. Omdat de vragenlijst direct door de inspecteurs wordt gebruikt, zijn gebruiksvriendelijkheid en betrouwbaarheid erg belangrijk. Van belang hierbij was dat er geen training nodig zou zijn en dat de inspecteurs de vragenlijst snel en betrouwbaar kunnen gebruiken en dat die vragen bevat die zij herkennen als duidelijk en relevant voor hun werk.

Vragenlijst-items zijn ontwikkeld op basis van de bestaande Storybuilder-modellen. Op basis van historische gegevens is bepaald of voor bepaalde aspecten vragen ontwikkeld moesten worden en welke antwoordmogelijkheden moesten worden opgenomen. We streefden ernaar vragen te ontwikkelen die feitelijk waren in plaats van evaluatief;

zo kort mogelijk; expliciet in plaats van impliciet; en specifiek in plaats van generiek. Sommige variabelen die in Storybuilder werden gebruikt konden niet worden overgezet naar een gebruiksvriendelijke vraag in de lijst; deze zijn daarom geschrapt.

Verfijnen, testen en implementeren
De items in de vragenlijst zijn verfijnd door middel van vele iteratieve reviews. Er is regelmatig overleg geweest met een groep experts. Daarnaast zijn twee voortesten gedaan met inspecteurs die in het veld actief zijn, één in persoon en één via een online systeem. Uit deze tests bleek dat het MLvO-instrument kan worden gebruikt om veel van de complexiteit van de arbeidsongevallen waarmee de inspecteurs dagelijks worden geconfronteerd, systematisch vast te leggen. Na het ontwikkeltraject is de MLvO nu een gebruiksvriendelijke vragenlijst die direct wordt gebruikt door de inspecteurs van de arbeidsinspectie.
Op 1 januari 2020 is de vragenlijst in gebruik genomen. Het monitoringsysteem is nu een vast onderdeel van het werk van de arbeidsinspecteurs. Het systeem wordt gebruikt voor alle ernstige arbeidsongevallen die worden gemeld. Inspecteurs worden gevraagd om de vragenlijst in te vullen als zij het dossier van een ongeval afsluiten. Voor 2020 zijn gegevens verzameld over 1.602 ernstige arbeidsongevallen. In hoofdstuk 4 worden voorbeelden gegeven van het soort informatie dat nu beschikbaar is. Ook wordt zichtbaar hoe de MLvO zich verhoudt tot voorgaande vlinderdasmodellen.

Suggesties voor gebruik en doorontwikkeling
De komende jaren zullen er steeds meer gegevens uit de MLvO-vragenlijst beschikbaar komen. Deze kunnen worden gebruikt om over arbeidsongevallen in Nederland te rapporteren en om deze te volgen. Geleerde lessen kunnen worden gedeeld met het publiek, net zoals dat nu gebeurt met gegevens uit Storybuilder (zie bijvoorbeeld de website www.lerenvoorveiligheid.nl). De gegevens kunnen ook worden gebruikt door de arbeidsinspectie om hun werk verder te richten en ze kunnen gebruikt worden om beleidsontwikkeling te ondersteunen. De invoering van de MLvO biedt bovendien extra mogelijkheden om nieuwe en opkomende risico's te bestuderen en om daarbij een diepgaand inzicht te verschaffen in specifieke soorten arbeidsongevallen.

Arbeidsongevallen zijn divers en ook de manier waarop we (veilig) werken ontwikkelt zich. De complexiteit en diversiteit aan arbeidsongevallen en nieuwe ontwikkelingen maken continue validatie, onderhoud en verbetering van de MLvO noodzakelijk. Het RIVM beveelt daarom aan om het instrument continu en actief te beheren. Ten slotte kan de MLvO breder toegepast worden, bijvoorbeeld door (grote) bedrijven, brancheorganisaties of andere intermediaire organisaties. De MLvO kan (mogelijk met aanpassingen) door deze groepen gebruikt worden om zelf informatie over arbeidsongevallen op een systematische manier te verzamelen, te ordenen en te duiden.

1 Introduction

Every year many thousands of occupational accidents occur. These accidents can have serious consequences for the victims, their families and co-workers and for the workplaces where the accidents have occurred. Worldwide, the International Labour Organization estimates that approximately 340 million workers are victims of an occupational accident each year. In the Netherlands 245,000 employees aged between 15 and 75 (3.3% of the total) are estimated to have had an occupational accident in 2019 (Venema, 2020). Almost half of those (1.5% of the total) reported that they were away from work for at least a full day as a result of the accident.

In the Netherlands, when an occupational accident is serious (resulting in a permanent injury, hospitalisation or death), the organisation at which the accident happened is legally required to report it to the Netherlands Labour Authority (NLA). This inspectorate investigates both the accident and the workplace. In 2019 the NLA received approximately 4,500 reports of serious occupational accidents and investigated approximately 2,200 of these accidents, which had led to 69 deaths. The NLA further reported that the number of occupational accidents had increased over the past five years, although they noted that this might be due in part to economic growth in that period (Inspectie SZW, 2020).

The Dutch Ministry for Social Affairs, the NLA and the National Institute for Public Health and the Environment (RIVM) cooperate to draw lessons from these accident reports. This cooperation started in 2003 when the Ministry initiated a programme in which data on serious occupational accidents gathered by the NLA was systematically analysed by trained analysts working for RIVM. For this purpose, a ‘bowtie’ model was developed called Storybuilder. More than 31,000 occupational accidents with more than 32,000 victims (that happened from 1998 up to and including 2014) have been analysed using the model. The data are still used to inform policy makers and safety professionals. The data and model have also been used to develop a quantitative model for occupational risks (Aneziris et al., 2009), custom software (Sol et al., 2013) and practical tools to be used by safety professionals in their companies (e.g. Bellamy et al., 2018; Jørgensen, 2016).

In 2018 it was decided that a new approach was needed and a new Monitoring System for Learning from Accidents (MLfA) was developed. The MLfA should still be usable for all serious reported occupational accidents and should still provide insight into the causes and consequences of these accidents. The MLfA should, however, no longer require extensive work by trained analysts but should instead be used directly by labour inspectors. The system should also integrate well with modern data analysis tools.

Given these design goals it was decided to develop a new questionnaire for use by inspectors as an evolution of Storybuilder. The questions in the MLfA were developed directly from the Storybuilder model using the many years of data in the Storybuilder database. The MLfA does not fully replicate Storybuilder; a direct mapping of the model was not needed or considered feasible. The user-friendliness and reliability of the questionnaire were considered most important.

In this report we show how the MLfA was developed. In Chapter 2 we introduce the basics of the Storybuilder method, the models and the data. In Chapter 3 we explain how these models and data were used to develop and structure the MLfA questionnaire. Chapter 4 includes examples of the type of information that is available in the MLfA. An annotated example questionnaire is included in Appendix C.

2 Storybuilder: method, models and data

The Storybuilder method, models, and databases were developed with the aim of systematically categorising and analysing serious occupational accidents in order to better understand these accidents: their causes and effects. In this chapter we will first discuss the Storybuilder method and 'bowtie' models in general. We will then briefly describe the main aims of this modelling approach and how it has been developed and used over the years; further details are available in a separate report (Sol et al., 2013) as well as in published papers (e.g. Bellamy et al., 2007; Hale et al., 2007).

2.1 Storybuilder as a bowtie model

At its core Storybuilder is a bowtie model that is used to describe the (potential) failures preceding a particular 'centre event' as well as the (potential) consequences that can follow from that event (Sol et al., 2013). In between events barriers are modelled which represent points at which a causal chain may be stopped or moderated. The name bowtie derives from the shape of the model when it is drawn. Events, causes and the barriers are modelled visually as connected boxes, ovals or rhombuses. Different causes, barriers and events can both precede the centre event and follow after it, giving rise to the distinctive bowtie shape (see Figure 1).

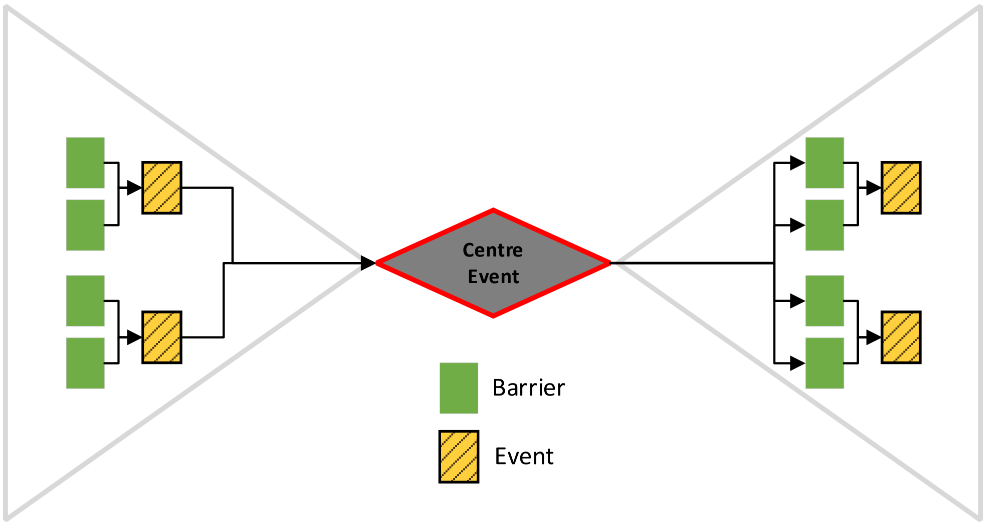


Figure 1 General shape of a bowtie model (simplified)

Bowtie models were first created by Nielsen (1971) as an extension and combination of 'failure trees' and 'event trees', which had been used until then (de Ruijter & Guldenmund, 2016). Bowtie models have since grown in popularity and are now commonly used by companies and organisations that perform high-risk tasks to manage the risks associated with those tasks. A key advantage of a bowtie model compared with other models is that multiple related scenarios can be understood and visualised together. Particular accidents that have occurred and scenarios for accidents that could occur can share the same centre event. Each individual accident can then be represented by a single path through a combined model. This also means that they can be combined into one visual representation and integrated into one underlying dataset. Figure 2 shows an example of this: the path for a specific accident is marked in red. In this hypothetical example a victim fell from scaffolding because he or she tripped over some loose objects. Crucially the bowtie model allows an analyst to show multiple related accidents (also called scenarios) in the same diagram – provided that they share the same centre event. So, in this example another accident where the victim fell from scaffolding could be added, but this accident might have a different path.

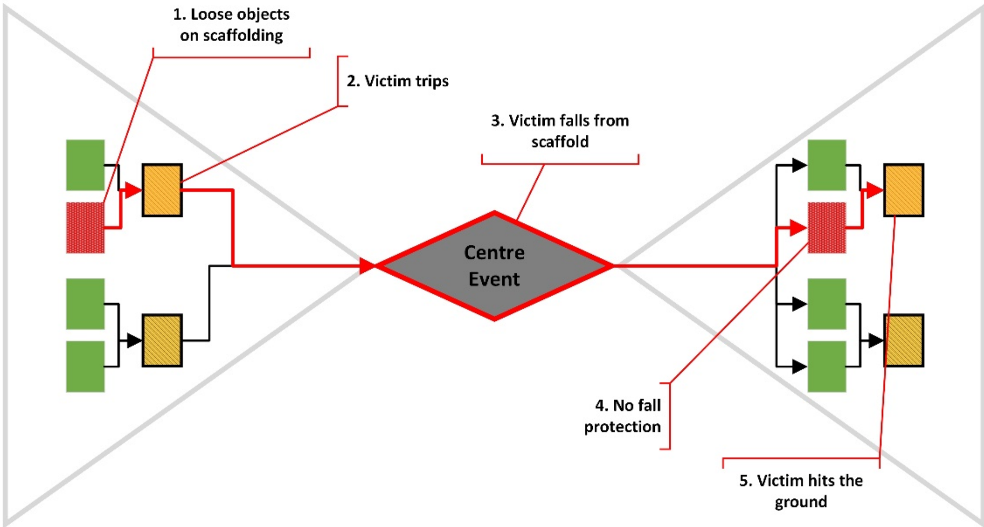


Figure 2 Possible (accident) path through a generic bowtie model

De Ruijter and Guldenmund (2016) reviewed different bowtie models presented in the literature. From their analysis it is clear that there are many similarities between the different models in use today, although there are of course also differences in details and terminology. Bowtie models all include:

- A centre event that is used as a point of convergence in the model (also referred to as a critical event or top event).
- A (series of) threat(s) or cause(s) on the left side of the diagram and a (series of) consequence(s) or outcome(s) on the right.
- A (series of) barrier(s) across the left and right sides of the diagram, which represent points at which a causal chain may be stopped or moderated, either to prevent the centre event from occurring (preventive barriers) or to prevent or limit unwanted consequences (repressive barriers).

Most bowtie models also include a more or less strictly defined method the role of the management system in the maintenance of a barrier's function. In this chapter we will use the terminology used in the Storybuilder methodology. Readers who are interested in the extensive work that was done to quantify the risk of these occupational accidents are referred to publications on the Workplace Occupational Risk Model (e.g. Aneziris et al., 2009; Hale et al., 2007). For an overview of other bowtie models, see De Ruijter and Guldenmund (2016).

2.2 Storybuilder accident types

For the development of Storybuilder a group of 36 centre events was derived from serious occupational accidents. The accidents were investigated by the NLA and the reports were subsequently analysed by researchers. For each centre event a bowtie model was developed. Thus each bowtie model and centre event represents a specific accident type (for example, falling from scaffolding or coming into contact with the moving parts of a machine).
For each accident type, the moment at which 'control is lost' and the 'hazardous agent is released' is chosen as the centre event (Sol et al., 2013). The bowtie begins 'at the point at which the person becomes exposed to the hazard represented by the bow-tie, e.g. when that person climbs the ladder for whatever purpose' (Bellamy et al., 2007, p. 738). Once a centre event has been chosen, all further events included in that particular model must be causally related to that event (Bellamy et al., 2007). In principle, any event can be validly chosen as a centre event but the choice of centre event is crucial to arrive at a meaningful analysis (Bellamy et al., 2007).
The goal of developing Storybuilder was to identify the causes of accidents within the scope and (partial) control of the companies in which the accidents occurred (Sol et al., 2013). Storybuilder does not expand into broader social contexts – neither those related to causes (e.g. societal or economic influences) nor those related to consequences (e.g. medical follow-up).

An example of developing a Storybuilder model

An analyst tries to build a model for the risk of falling when working at height. To that end she analyses an occupational accident where an employee fell from scaffolding. Within the Storybuilder model she defines the moment at which control over the risk was lost as the centre event. This is the moment at which the employee 'started falling'. All other elements in the model are causally related to that event.
Note that in this case the centre event is not the moment that the employee hits the ground. This typically occurs on the right side of the diagram. Repressive barriers such as fall protection could still prevent the worst consequences. Other factors such as the height from which the victim fell may influence the amount of energy or 'dose' that impacts the victim.

The 36 centre events and the related bowties or accident types were iteratively developed by analysing and modelling real-life accidents. In all cases these were serious and reportable occupational accidents. The accidents were: reported to the NLA by companies, as required by law; investigated and described by inspectors as a part of their normal responsibilities; and, finally, analysed and modelled by the group of researchers.
A two-pass approach was used during development. First, a draft bowtie was defined, typically based on about 100 similar accidents. After this first pass all available accidents from 1998 up to 2004 were analysed in a second pass. In this phase extensive discussions were held to

harmonise and improve the models. These reflections often led to additional descriptions and examples. Sporadically these reflections also led to re-analysing substantial numbers of accidents. In parallel to this scientific development of the models, a Storybuilder software program was developed.
Two additional accident types – acute noise and ionising radiation – were identified but not enough data were available for the creation of a full model. The full approach, organisational structures, software programs and processes used to optimise quality, consistency and uniformity are described in detail in Sol et al. (2013). A full list of accident types is included in Appendix A.

2.3 Data gathering and data entry

The 36 bowtie models were largely completed in 2007 with approximately 9,000 accidents in the database (Aneziris et al., 2009). The bowties, the structure and the underlying data could be accessed using custom software. In addition, examples and technical reports were available for each accident type. Finally, the software and the anonymised data were made publicly available.

From then on, analysts updated Storybuilder with new data each year. New data were gathered up to and including the year 2014. The database now contains more than 31,000 serious occupational accident reports involving more than 32,000 victims.

An example of adding new data to the Storybuilder database

To add data on a new occupational accident to the Storybuilder database, an analyst would read a report from the NLA about that accident and assign it to a model. For example, a worker was exposed to the risk of falling from height by climbing on and working on a ladder. Regrettably the worker fell from the ladder, so the analyst would use the model that contains the centre event 'Fall from ladder'.

The analyst would then record this new accident using this model. She would examine the most important events in a structured way: did the ladder break or did it slip? She would then examine which barriers failed to prevent the accident. She would look at the ladder's position, condition, fixing, etc. Finally, the analyst would examine the management factors that might have contributed to a barrier failing. In this case the inspector found that the company did not have adequate plans and procedures for ladder maintenance. The ladder was in a poor condition, which caused one of the rungs to break.

By reading and analysing the report and choosing a path through the different boxes that are part of this model, the analyst added a new path – and new data – to the Storybuilder database, in the accident type 'Fall from ladder'.

There are some limitations to the source material and source data. Sol and colleagues (2013) extensively described the data used to define the Storybuilder models. The data are selective in so far as they are limited to accidents reported to and investigated by the NLA. But not all accidents that occur have to be reported. For example: the labour legislation may not apply if a worker is self-employed; an accident may not be reportable if the consequences are minor; the NLA may not become involved if a worker has a traffic accident during work time but outside the company's premises.

2.4 Summary

The Storybuilder bowties form a (simplified) taxonomy of occupational accident types. Storybuilder was derived systematically by analysing a large number of serious occupational accident reports over many years. The lessons that were learned from the data were used, for example, to inform policy, to inform safety professionals, to develop tools and as a basis for a quantitative risk model. The Storybuilder models and the underlying data form the basis for the development of the MLfA.

3 A new monitoring system for learning from accidents

In the preceding chapter we examined the Storybuilder method, the origin of the method and the resultant database. This database has been in use for many years and is still used to inform policy makers and safety professionals. However, it was decided that a new approach was needed from 2018 onwards. The work required to add approximately 1,700 accidents to the database every year was extensive. At the same time the added value of these additional accidents was not always clear, and the involvement of inspectors was limited. Finally, the software that is used to store and analyse the Storybuilder data is quite old and does not provide all the modern features that are desired. Therefore, a new system was developed: the Monitoring System for Learning from Accidents (MLfA).

3.1 A new questionnaire for the labour inspector

Many of the design goals for the MLfA were the same as those that were relevant when Storybuilder was first developed. The system should, for example, still be usable for all serious occupational accidents that are reported to the NLA. The system should also be usable to gather key information about occupational accidents and their main causes. Finally, it was deemed important to ensure a degree of consistency and to make use of the Storybuilder model and all the data that had been gathered over the years.
Other design goals were new to the MLfA. The system should no longer require extensive work by trained analysts on each accident. Instead, the system should gather information directly from the inspector. The system should also integrate well with modern data analysis tools.

Given these design goals it was decided to develop a questionnaire for use by labour inspectors themselves. This questionnaire was intended to be an evolution of Storybuilder, with a strong focus on user-friendliness and reliability. This led to the following practical goals:

- *No or minimal training*: No or only very minimal training should be required for inspectors to use the questionnaire.
- *Quick to use*: The questionnaire should be usable for all serious occupational accidents (approximately 2,000 per year) and inspectors should be able to enter all the relevant data quickly.
- *Relevant and clear*: The questionnaire should be focused on those aspects that can be easily and reliably reported by inspectors. It is important that inspectors view the data entry as relevant and clear and related to their daily work.

Variables not adapted from Storybuilder to the MLfA

The aforementioned goals had a strong influence on the development of the questionnaire. As a consequence, some variables that had been used in Storybuilder do not have a counterpart in the MLfA, while others are present only at a lower level of detail. The level of detail in the MLfA differs for each question. The way in which the questions were formulated is discussed extensively later in this report; here we will discuss the two most important variables that were not adapted to the MLfA: 'barrier tasks' and 'management delivery systems' (Sol et al., 2013).

Barrier tasks and management delivery systems are used in the Storybuilder method to analyse the causes of each failed barrier separately and in detail. For each failed barrier the analyst indicated how the failure occurred, by considering the following question: was the barrier not provided, used, maintained or monitored? The analyst then looked at the potential failures in the management system that underpinned each problem and those were categorised as well. Were there, for example, shortcomings with respect to plans, procedures, or materials. This aspect of the Storybuilder model was not directly replicated in the MLfA. It was found that it made the questionnaire too long and complicated. Inspectors would always have to very carefully relate their responses to a specific barrier failure, which would also increase the need for training.

Choosing to no longer capture some variables for all occupational accidents was considered necessary. However, provisions were made to still provide insights into the underlying causes of accidents by conducting specific studies. These include, for example, studies on machine accidents (Van Kampen et al., 2019) or specific contributing factors such as distraction (Sol et al., 2020). In addition, provisions were made to temporarily extend (for example, for six months) the monitoring system with extra questions to gather information for specific research questions.

Designing and testing the questions
In keeping with best practice for questionnaire design (e.g. Dolnicar, 2013; Krosnick, 2010) and as a general philosophy, it was decided that the questionnaire items in the MLfA should be: factual rather than evaluative; short rather than long; explicit rather than implicit; and specific rather than generic. To help develop such questionnaire items, the existing Storybuilder models and data were an essential asset. The data and models were used to assess whether a particular variable should be included in the questionnaire and to help design the question and the answer options. In addition, extensive pre-testing was done to refine the questionnaires (see Section 3.7).

The development of the MLfA is discussed in more detail in Sections 3.2 and 3.3. In Section 3.2 we explain how we used the Storybuilder variables and Storybuilder data to design questionnaire items for the MLfA. In Section 3.3 we explain one variable in more detail: the safety barriers. We illustrate how we used multiple Storybuilder boxes (explained below) and data to develop questionnaire items for the safety barriers. In Section 3.4 we provide an overview of the boxes that were adapted from Storybuilder into questions for the MLfA (more detail is available in Appendix B). In Sections 3.5 and 3.6 we discuss the structure of the questionnaire: how it was made specific to each accident type and how the accident type is determined by the user. Finally, in Sections 3.7 and 3.8 we examine the pre-tests that were carried out and the implementation of the questionnaire itself.

3.2 Using Storybuilder 'boxes' to design questionnaire items

As discussed above, the 36 accident types were the main organising principle of the Storybuilder database. The other parts of the model were defined for each individual accident type. In the Storybuilder software, analysts select descriptive 'boxes' in a visual bowtie diagram. Each box can be seen as a variable or a part of a variable that describes a part of the accident.

Crucially, the Storybuilder boxes have a well defined typology and are grouped together in meaningful ways. For example: some boxes denote a barrier; other boxes denote an event; and other boxes again are used to denote an activity. In addition, boxes are grouped together in a way that is defined by the method. The analyst selects those boxes that are applicable to the accident.

Different types of information from these boxes were used to develop the survey questions in the MLfA. We used:

- the types and meaning of boxes (see 3.2.1);
- the grouping of boxes (see 3.2.2);
- the hierarchical structure of groups of boxes (see 3.2.3);
- the data gathered for these boxes (see 3.2.3).

In this section we will show the general process that was used to develop a survey based on the Storybuilder boxes. This was an adaptation of most of the variables from Storybuilder. Adapting the Storybuilder barriers was more complex; this will be discussed separately in Section 3.3.

3.2.1 *The types and meaning of boxes*

In the Storybuilder software analysts select descriptive boxes from a visual diagram. Each type of box has a narrowly defined meaning. Figure 3 shows some examples of these box types, the loss of control event (LCE), the barrier failure mode (BFM), the activity of the victim (A) and the equipment type (ET).

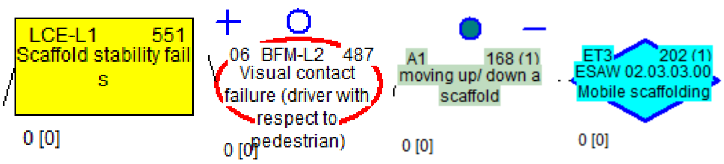


Figure 3 Example of Storybuilder boxes

From left to right: a loss of control event; the failure mode for a barrier; the victim's activity; the particular type of equipment. The numbers indicate the number of accidents and number of victims *[in brackets]* that are selected in the visualisation (0 in this case).

Every bowtie model (each accident type) contains several boxes of the box types relevant to that accident. Each box type has a distinctive visual appearance and is associated with a specific code and definition. Each individual box has a descriptive name as well as a more extensive description in Dutch and English. See Sol et al. (2013) for further details. Relevant meaning is encoded in each box. Yellow rectangular boxes, for example, denote a 'loss of control event'. These are used to capture the chain of events and are marked with the box code 'LCE'. By selecting this type of box, the analyst is in effect saying: 'This particular event occurred.' Loss of control events are available for every accident type and are specific to that type. These events can precede or come after the centre event in the bowtie. If an analyst selected the yellow box shown in Figure 3 he would be saying: 'The scaffold stability failed in this accident.'

The same conventions are used for the other accident types, although these boxes of course describe different events. For example, for an accident with a ladder a yellow LCE box marked 'The ladder moved unexpectedly' is available, and for an accident where a worker was hit by a vehicle a box reading 'The vehicle and pedestrian movements were not separated' could be chosen.

3.2.2 *The grouping of boxes*

The visual connection between boxes also has a meaning: related boxes are connected to a so-called group box to make their relatedness explicit. To illustrate how this works, we show a group of loss of control events in Figure 4.

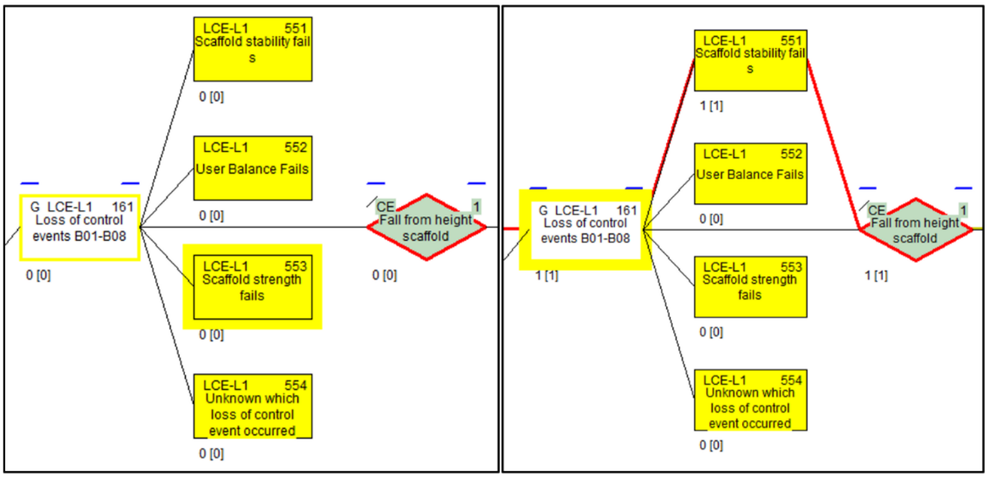


Figure 4 Grouping of boxes in Storybuilder (left) and entry of a single accident path (right)

The numbers indicate the number of accidents and the number of victims *[*in brackets*]* that are selected in the visualisation.

Figure 4 shows a small part of the bowtie model that describes accidents where a worker falls from scaffolding. The figure shows a group of boxes that describe the events that occurred just before the centre event (the loss of control events). Four possible events are shown:

1. The scaffolding stability failed (for example: the scaffolding fell over or shook).
2. The user balance failed (for example: the victim fell over the edge of the scaffolding).
3. The scaffolding's strength failed (for example: the flooring of the scaffolding broke).
4. Something happened but it was unknown which of the three above events occurred (for example: it was unclear whether scaffolding or user stability failed).

When adding a new accident to the dataset, the analyst would choose from the options in this grouping the one that is the most applicable. On the right-hand side of Figure 4 we can see how this works; here a single accident is added to the database as a red line. It was technically possible for analysts to choose multiple boxes from a single grouping; whether this is allowed depends on the specifics of that group and is manually checked during quality assurance. It was also possible for analysts to add boxes to the model. This was essential during the development of the models but was more rare and only done in a controlled manner during the later phases of the project (see also Section 2.3).

In some cases, the content and grouping of boxes is sufficient to develop the (first version) of a questionnaire item for the MLfA. The loss of control events shown above were used to develop the questionnaire item shown in Table 1.

Table 1 Question 'How did the victim fall from the scaffolding?'

Question	How did the victim fall from the scaffolding?
Subtext	Choose what happened first.
Possible responses	The scaffolding fell over The scaffolding moved suddenly The victim lost his or her balance (scaffolding remained standing) The scaffolding collapsed The scaffolding broke Unknown
Further settings	Only asked for a 'Fall from scaffolding' accident type. Respondents can choose only one option. A response is required to complete the questionnaire.

For loss of control events the Storybuilder boxes can be adapted to questionnaire items in a relatively straightforward manner, although it should be noted that the adaptation is not a 'one-to-one' conversion. For this example, the following changes were made:

- An explicit question was posed rather than relying on an abstract group box description.
- To prevent ambiguity and to reduce the need for training, a subtext was added. This subtext states that (when in doubt) the inspector should choose the event that occurred first (e.g. covering cases where the victim lost his or her balance only after the scaffolding moved suddenly).
- The abstract descriptions and the grouping of boxes shown in Figure 4 were made more concrete for the response options in the questionnaire. For example, 'scaffold stability failed' was replaced with more specific language, stating that the scaffolding 'fell over' or 'moved suddenly'.

In this specific case the information that is captured in the MLfA is expected to be very similar to the data available in Storybuilder. Groups of boxes of the same type were converted in a similar way across all accident types, each group of boxes being evaluated separately.

3.2.3 *Hierarchical structure and historical data*

The types of boxes, their meaning and their position was mainly determined during the initial development of the Storybuilder models. Subsequently, as data were gathered over the years, a further hierarchical level was sometimes added to a group of boxes. These added boxes gave more precision to Storybuilder but could make it more difficult to design a usable questionnaire item. Figure 5 shows an example of this. The figure shows the part of the bowtie model that captures a victim's activities prior to the accident (in this case being struck by a vehicle).

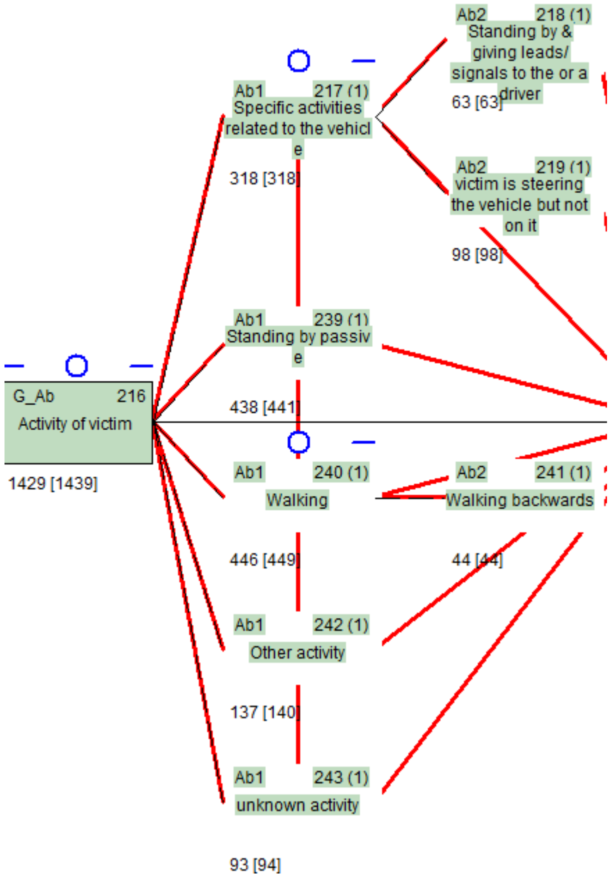


Figure 5 Hierarchical structure and data in Storybuilder showing victim activities prior to being struck by a vehicle
The numbers indicate the number of accidents and the number of victims *[]* that are present in the database for the accident type.

The added hierarchical levels (marked Ab2) give a more precise description of what the victim was doing before the accident. The data present in the database can also be used to refine our understanding of what was going on. Boxes at the lower hierarchical level (Ab2) are selected conditional on the 'parent box' chosen. In the example shown, analysts were only allowed to select the box labelled 'Walking backwards' when the box 'Walking' had been chosen first. It is important to note that the analyst is not obligated to choose one of the boxes on the lower hierarchical level. So if the direction of walking is unknown, the analyst will select 'Walking' but not 'Walking backwards'.

It can be challenging to convert these groupings of boxes with an added hierarchical level into one or more simple questionnaire items. The box's meaning, the hierarchical structure and the number of accidents that historically occurred provide a starting point. However, a further judgement must be made, for example about the expected relevance of a variable and the number of questions that would be needed to fully capture it. These judgements were made by the project team and tested with NLA inspectors in several testing sessions (see Section 3.7).

For the group of activity boxes shown in this section a single questionnaire item was designed, as shown in Table 2.

Table 2 Question 'What did the victim do just before the accident?'

Question	What did the victim do just before the accident?
Subtext	Choose what best describes the victim's activities.
Possible responses	Controlling the vehicle from outside the vehicle Providing directions for the driver Guiding a load Other activity related to the vehicle (e.g. maintenance, cleaning, loading/unloading) Passively standing around Walking Other Unknown
Further settings	Only asked for the 'Victim struck by vehicle' accident type. Respondents can choose only one option. A response is required to complete the questionnaire.

For the development of the question about the activity of the victim it should again be noted that the adaptation is not a one-to-one conversion. Notable modifications in this example were:

- An explicit question was posed rather than relying on an abstract group box as in Storybuilder.
- To prevent ambiguity and to reduce the need for training, a subtext was added stating that the inspector should choose the option that best describes the victim's activities.
- The hierarchical levels were integrated into a single question in this case.

Some activities present in Storybuilder were not used in the questionnaire, due to a low number of cases and/or limited relevance. For example, the direction of walking (i.e. backwards) was dropped. Whether hierarchical levels or specific response options were dropped or converted into additional questions depended on the content and was specifically determined for each variable in Storybuilder. This approach was used throughout, to develop the MLfA for all accident types.

3.3 Addressing the safety barriers

In the preceding section we described how survey questions were designed on the basis of Storybuilder boxes. We relied mainly on the meaning of boxes, their grouping and structure and the data that had been gathered for accidents that occurred between 1998 and 2014. Adapting the preventive barriers from Storybuilder to the MLfA questionnaire was more complex. Therefore, we address them separately in this section.

For the preventive barriers it proved to be necessary to analyse boxes of different types simultaneously as input for the development of questions in the MLfA. In the following we illustrate the input we used and how we designed a compact block of questionnaire items that is titled: 'What went wrong?'.

3.3.1 Multiple box types and historical data in Storybuilder

'Barriers' refers to measures or potential measures that (could) prevent or moderate the causal chain. Barriers are essential in any bowtie. In Storybuilder, several boxes were used to model the barrier concept. Figure 6 shows an example for the accident type 'Fall from ladder'.

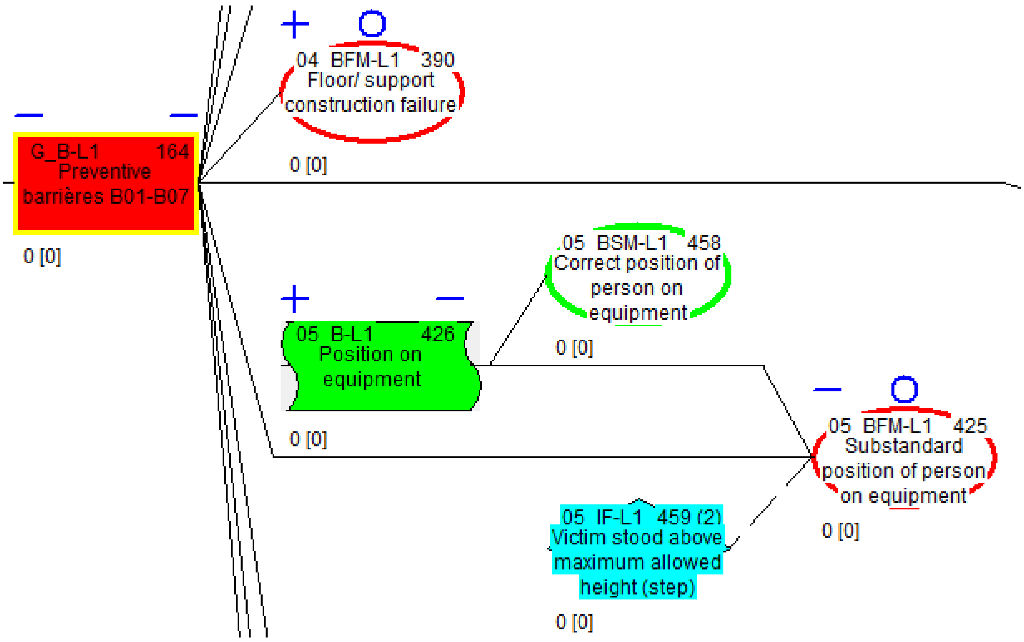


Figure 6 Box types used to model barriers in Storybuilder.
The numbers indicate the number of accidents and number of victims [] that are selected in the visualisation (no accidents are selected in this visualisation).

In Figure 6 we can see the five box types that were used to model barriers in Storybuilder. In Table 3 below we describe the appearance, meaning and available data of the different box types.

Table 3 Box types used to model barriers in Storybuilder

Box types and appearance	Meaning	Data
The grouping (group box) of related barriers (red rectangle)	Used to group related barriers.	Selecting this box communicates that the barriers in the grouping were evaluated.
The barrier (green rectangle)	Description of the barrier.	Used to structure the diagram and to define the barrier itself.
The barrier's 'failure mode' – the fact that the barrier failed (red oval)	Denotes that the barrier failed. The box description gives information and examples about what 'failure' means.	Selected if the analyst found that the failure of the barrier was relevant to the accident.
The barrier's 'success mode' – the fact that the barrier functioned successfully (green oval)	Denotes that the barrier was successful. The box description gives information and examples about what 'success' means.	Selected if the analyst found that the success of the barrier was relevant to the accident. Barrier success is used infrequently in practice (more often in repressive barriers).
The incident factors (blue rhombus)	The incident factors contain additional information about a barrier and its failure or its success. Many incident factors are used to describe more concretely the way in which a barrier failed.	Incident factors are selected when they apply to the accident. This selection is conditional on the barrier having failed.
The state of a barrier or group of barriers was unknown (grey oval). This box type is not shown in Figure 6.	Denotes that the success or failure of the barrier or group of barriers was unknown.	Typically used to indicate for a group of barriers that it is unknown which barrier failed.

The table and figure above give an overview of the box types that are relevant to the barrier concept in Storybuilder. From this it can be seen that the modelling of Storybuilder barriers is multifaceted. As a further complexity the individual Storybuilder bowties differ substantially in the number of barriers and incident factors that are present as well as in their level of detail and the complexity of the descriptions. Finally, from the historical data we can see that some incident factors or barriers do not apply to many accidents.

3.3.2 *Barriers in the MLfA – identifying failure mechanisms*

Two main options were explored for adapting the safety barriers in Storybuilder to the MLfA questionnaire. One option was to base questionnaire items either exclusively on the safety barriers or exclusively on the incident factors. Both had advantages but also serious disadvantages. The safety barriers are an essential part of the Storybuilder model, and the analysts always considered all the safety barriers for an accident type. In addition, the safety barriers are

designed to be complete for all possible failure mechanisms whilst the incident factors are not. On the other hand, the descriptions used for the safety barriers are often quite broad and abstract whereas the incident factors are described in a more concrete and specific way. Therefore, the incident factors are much more suitable for inclusion in a user-friendly questionnaire.
To balance these considerations, the barriers, barrier failure modes, incident factors and descriptions for each related box were analysed simultaneously. A box was used to develop a questionnaire item if:

- the box and its description modelled a failure mechanism – a way in which control over the hazard could be lost;
- the failure mechanism played a role in at least 5% of the historical accidents of the same type.

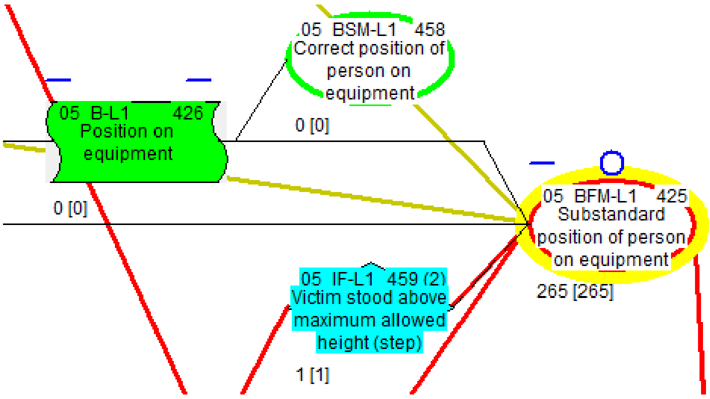


Figure 7 Box types and data used to model barriers in Storybuilder
The numbers indicate the number of accidents and number of victims [] that are selected in the visualisation (all accidents where a victim had a substandard position on equipment are selected in this example).

Figures 6 and 7 show a barrier failure mode as a red oval marked 'Substandard position of person on equipment' and an incident factor labelled 'Victim stood above maximum allowed height (step)'. From the diagram we can see that 'Victim stood above maximum allowed height (step)' (incident factor) is modelled as a specific way for a person to have a 'Substandard position on equipment' (barrier failure mode). Both are only applicable to accidents where a victim fell from a ladder.
In Figure 7 we can further see the number of accidents of this type that have occurred historically. A substandard position was found as a contributing factor in 265 accidents; this is 9.5% of the 2,727 accidents of that type. The incident factor was, however, found only once. The questionnaire item for the MLfA was therefore developed primarily from the barrier and its descriptive text (the red oval). The questionnaire item adapted from this box reads:

'The victim did not stand correctly on the ladder (e.g. due to overreaching or standing with one foot on something else).'

Instead of using the more abstract wording of Storybuilder, 'Substandard position of person on equipment', the item is formulated more concretely: 'The victim did not stand correctly on the ladder'. This item also gives two examples in parentheses of what it means to 'not stand correctly' on a ladder. The examples in parentheses increase the length and complexity of the item but were added to facilitate comprehension in this case.

A set of failure mechanisms
A full set of failure mechanisms was identified for each accident type. As a first step, draft questionnaire items were constructed. The aim of these was to explore whether the failure mechanism could be described in text suitable for use by inspectors. During this development we assessed whether there was overlap between different items. The drafts were reviewed and iteratively refined by two researchers; then further reviewed by two other researchers who were not directly involved in the project. During these reviews the questionnaire items were also made more consistent between the different accident types.

In total, 485 questionnaire items were developed in this way, an average of 13 to 14 items for each accident type. For each item, that is relevant to the accident type, the respondent indicates whether the mechanism: 1. contributed to the accident; 2. did not contribute to the accident or it is not applicable; or 3. Do not know. As an example, Table 4 shows the items for the accident type 'Fall from scaffolding'.

Table 4 Questionnaire items related to barriers for the accident type 'Fall from scaffolding'

What went wrong?	Contributed to the accident	Did not contribute/ not applicable	Do not know
The edge protection was not present.	❍	❍	❍
The edge protection was incomplete.	❍	❍	❍
The edge protection was defective.	❍	❍	❍
The edge protection had been (temporarily) removed.	❍	❍	❍
The scaffold was not properly constructed.	❍	❍	❍
The floor of the scaffold was in a poor state.	❍	❍	❍
What went wrong?	**Contributed to the accident**	**Did not contribute/ not applicable**	**Do not know**
The scaffold had been placed on or against an unsuitable surface.	❍	❍	❍
The scaffold was placed in an area that was not protected against external forces (e.g. protected against collision with a vehicle or bumping by a hoisted load).	❍	❍	❍
The scaffold was not properly anchored.	❍	❍	❍
The stabilisers for the scaffold had not been deployed.	❍	❍	❍
The brakes for the scaffold had not been engaged.	❍	❍	❍
What went wrong?	**Contributed to the accident**	**Did not contribute/ not applicable**	**Do not know**
The victim was climbing or hanging on the outside of the scaffold.	❍	❍	❍
The victim slipped or tripped.	❍	❍	❍
The victim lost his or her balance for unknown reasons.	❍	❍	❍

3.4 Overview of boxes and variables

In the preceding paragraphs we described how survey questions were designed on the basis of Storybuilder boxes. This process was applied to all the different types of boxes that are available in Storybuilder. In Table 5 we show the variables (boxes from Storybuilder) that were adapted for the MLfA; a more detailed version of this table is available in Appendix B.

Table 5 Overview of the types of variables adapted to the MLfA

Variable	Role and relevance	Use in the MLfA
Centre event	Defines the moment at which control was lost over the main hazard and energy was released.	At the start of the MLfA questionnaire, this is the accident type.
Activity of the victim	Describes the activity or activities that preceded the accident. Also marks the start of the bowtie and the exposure of the victim to the risk of the centre event.	Multiple-choice questionnaire items with pre-determined options for each accident type. Inspectors can select one answer from the list.
Equipment type*	Encodes the (type of) equipment in connection with which the accident happened.	For some accident types a multiple-choice questionnaire item with pre-determined options is used. For other accident types a text lookup interface is used.
Loss of control events	Denotes essential steps in the chain of events that led to the accident or that came after the accident.	Multiple-choice questionnaire items with pre-determined options for each accident type. Inspectors can select one answer from the list. Only events preceding the centre event were used in the MLfA.
Dose-determining factors	Influence the severity of the consequences of a centre event. Used to quantify the amount of hazardous energy that struck the victim.	Multiple-choice questionnaire items with pre-determined options for each accident type. Inspectors can select one answer from the list.
Part of the body that was injured*	Indicates the part of the body that was injured in the accident.	Converted to a questionnaire item with pre-determined options; inspector can choose all options that apply.
Type of injury sustained*	Indicates the type of injury sustained by the victim.	Converted to a questionnaire item with pre-determined options; inspector can choose all options that apply.
The final outcome for the victim*	Used to indicate the consequences of the accident for the victim (permanently injured/injured temporarily/deceased).	Multiple-choice questionnaire items with pre-determined options for each accident type. Inspectors can select one answer from the list.
Failure or success of preventive barriers, and related incident factors.	Preventive barriers refer to (potential) measures that (could) prevent the centre event from occurring; incident factors provide additional insight into mechanisms by which a barrier failed.	Adapted into a matrix of ‘What went wrong?’ questions (see Section 3.3).

Variable	Role and relevance	Use in the MLfA
Failure or success of repressive barriers.	Repressive barriers prevent or limit the effects of a centre event. Repressive barriers are relevant after the centre event has already occurred. Examples include fall protection and safety goggles.	Converted to two questionnaire items for each repressive barrier. These are standardised across similar accident types. The questions address the actual use and necessity of the barrier and whether it worked as intended.

Variables marked * use the European ESAW classification system (European Statistics on Accidents at Work (ESAW) – Summary methodology, 2013).

3.5 Structure of the questionnaire

The Storybuilder accident types form a (simplified) taxonomy of occupational accidents and, as discussed in the previous sections, each accident type is constructed from many different (types of) boxes. The accident types are used as the main organising principle in the MLfA. A separate questionnaire was developed for each accident type. Figure 8 shows the overall structure of the MLfA.

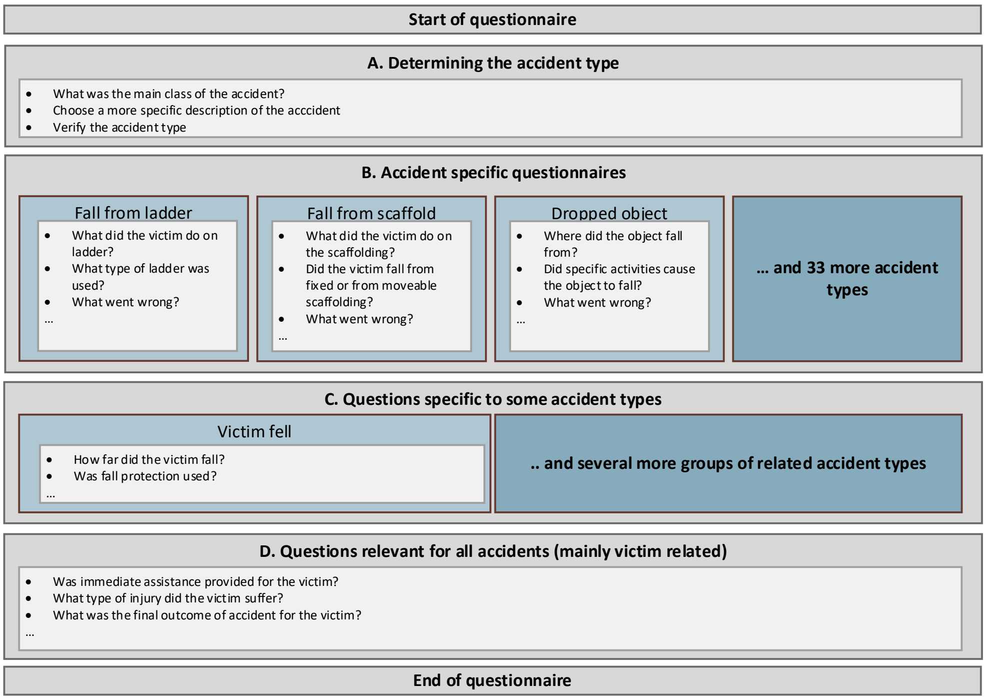


Figure 8 Overall structure of the MLfA

The structure of the MLfA shown above makes it possible for questions to be specific to the type of accident and therefore easier to answer. The first part of the questionnaire (Part A) is focused on determining the accident type. Determining the accident type correctly is crucial, as it ensures that the questions that follow are applicable to the accident under investigation.

Accident-specific questions, such as questions related to the activities preceding the accident, are shown in part B. For example:

- For accidents where the victim fell from scaffolding, the question used is: 'Did the victim fall from fixed or from moveable scaffolding?'

- For accidents where the victim was struck by moving parts of a machine, the question used is: ‘With what type of machine did the victim come into contact?’.

Some other questions are relevant for and shared between several accident types (Part C) – in particular, questions on the dose-determining factors and repressive barriers (see Table 5). For example:
- For all accidents involving a fall: ‘What height did the victim fall from?’
- For all accidents involving a hazardous substance: ‘What were the characteristics of the hazardous substance?’.

Part D of the questionnaire is the same for all accident types. These questions are mainly related to the victim and his or her outcomes. In Appendix C an example is given for the accident type ‘Fall from scaffolding’; the questionnaire is presented as it would be for a user entering data on a fall from scaffolding.

3.6 Determining the accident type

Determining the type of accident that happened – the centre event that occurred – is one of the first steps in the MLfA. Accurately determining the accident type is very important because the applicability of many subsequent questions depends on it. The inspector chooses the accident type in the MLfA in three steps:

Step 1: Choose the main class of accident (9 options)
Two examples of the main classes are vehicular accidents and accidents where the victim fell from height.

Step 2: Choose an accident type
Each main class of accident is subdivided into more specific descriptions. For vehicular accidents, for example, the inspector can choose from: struck by moving vehicle; victim was controlling a vehicle and lost control; victim rode along with a vehicle and it went out of control; victim fell from a non-moving vehicle.

Multiple descriptions in this step can map onto the same type of accident/questionnaire. For example: the descriptions Victim was controlling a vehicle and lost control and Victim rode along with a vehicle and it went out of control both map onto the same questionnaire (accident type ‘In or on a moving vehicle with loss of control’). In doing so, we tried to make the choice of the correct accident type easier for the inspectors.
Step 3: Verify the accident type
Each choice is related to a Storybuilder bowtie and accompanying questionnaire. After choosing the accident type, the inspector is presented with a succinct description. He can then confirm his choice, ask for support from an expert or go back to step 1 or step 2 if he wants to choose another accident type.

3.7 Iterative development and (pre-)testing

There are many common recommendations for the development of questionnaires; some are supported by specific studies, while others might be seen as deriving from common sense or conventional wisdom (Krosnick, 2010). These recommendations are reflected in our design goals to develop questions that are factual rather than evaluative; short rather than long; explicit rather than implicit; and specific rather than generic. We also aimed to use simple, familiar words; avoid ambiguity; avoid negatively worded questions; and develop exhaustive and mutually exclusive response options.

The extent to which these design goals are met for a specific question is at least partly subjective. This reinforces the importance of (pre-)testing the questionnaire and making changes where necessary. Pre-testing can help to ensure that the questions are easy for users to comprehend, that they are motivated to answer thoughtfully and that the results are valid. Testing and refinement of the questionnaire was done using multiple methods and with multiple iterations. The following tests were done.

Iterative researcher reviews
In 2018 and 2019 the two main authors wrote the questionnaire items. When they were satisfied with a specific item, other researchers from the team independently reviewed it, providing feedback and suggestions. The questionnaire items were subsequently changed according to these suggestions if these were deemed an improvement. One further researcher from the same institute reviewed all items a second time. Again, if suggestions were deemed to be an improvement, the questionnaire items were changed. All reviewing researchers were experts in the field of occupational safety and experienced with the Storybuilder model.

Iterative reviews by domain experts
Further reviews and feedback were gathered from a broader group of domain experts. This group of experts met on a regular basis to discuss the development and implementation of the questionnaire. It included six domain experts that work for the NLA in various roles. Intermediate versions of the questionnaire were shown to this group regularly for feedback.

Pre-test workshops with inspectors
Inspectors from the NLA were invited to join one of two workshop sessions to discuss the questionnaire (six safety inspectors participated). These workshops were held early in the development of the questionnaires. In the workshops an early version of the questionnaires for five specific accident types was tested. For some questions two variants were tested sequentially and compared. First, the inspectors were asked to use the questionnaires to enter data on two real accidents they had recently investigated. Whilst using the questionnaires the inspectors were asked to ‘think aloud’ and share how they read and understood the questions. Subsequently the participants shared their interpretations and reflections. In a second step, all the inspectors filled out the questionnaire for the same accident, for which a specific case

selected by the researchers was used. The results were compared and discussed after completion.

During this pre-test we found that we could not adapt some parts of the Storybuilder model to the MLfA – at least, not without greatly increasing the length of the questionnaire and adding a requirement for training. The 'barrier task' model and 'management delivery system' model were in the end not adapted from Storybuilder to the MLfA.

Pre-test online
The feedback from the workshops was used to develop a new version of the questionnaire. This version was extended to 10 different accident types and was implemented in an online system. Eleven further inspectors were asked to participate in the online test. These inspectors entered data on 41 serious occupational accidents that they had investigated personally.

During the online test the inspectors entered the data at their own convenience. They were asked to enter data about accidents that they had investigated recently. The data were analysed and compared with the formal accident reports. In addition, inspectors were asked to reflect on the questionnaire in two steps. First, they were asked to reflect directly after data entry and to give their remarks in an open-text field in the questionnaire or via email. Second, the inspectors were approached after completing their accidents. In a semi-structured interview by telephone the inspectors were asked to reflect on the questionnaire and explain what they thought were its strong and weak points. We also asked the inspectors whether they felt the questionnaire was too long and if it was sufficiently detailed.

Inspectors were generally positive about the new questionnaire, noting that the questionnaire was easy to complete and that they could include many details about the accidents that they had investigated. The inspectors also made many useful suggestions. For example, they stressed the importance of accurately determining the type of accident that had occurred and asked for an easy way to access support (see also Sections 3.5 and 3.6).

3.8 Implementation

The MLfA was put into use on 1 January 2020 for all serious occupational accidents that were to occur in 2020 and on which the files would be closed in that same year. The inspectors could use the MLfA online via a web browser. Use of the MLfA was promoted in several ways: via email, on an internal webpage and in team meetings.

For the first year of implementation feedback was gathered from users in a variety of ways. Inspectors were offered the opportunity to give feedback in the questionnaire itself (which included a contact form), they could contact the project team directly via email or they could contact domain experts within the NLA in person. The feedback inspectors gave on the MLfA was generally positive. As expected, inspectors also reported some inconsistencies or bugs that could be fixed without disrupting data gathering. It was found, for example, that in exceptional cases what seems to be an occupational accident turns out to have been an acute medical event. This required a separate routing to ensure that inspectors were not forced to answer questions that were not applicable. On the basis of this feedback the monitoring system was updated in May 2020 and again in early 2021.

3.9 Summary

The boxes that are used in the graphical Storybuilder models were adapted to questionnaire items and variables for the MLfA. Sometimes the design of the questionnaire items could be taken directly from the structure of the Storybuilder model. At other times it was necessary to make a combined analysis of the model structure and the data that had been gathered historically.

Accident types are used as the main organising principle in the questionnaire; a separate route through the questionnaire was developed for each accident type. The questionnaire was extensively pre-tested and continuously refined. In this way, we aimed to ensure that the questions were easy for users to comprehend and that they were motivated to answer thoughtfully.

4 Getting to know the new data

In 2020, the first year's data was gathered by inspectors. This chapter will provide insight into the type of data that was gathered, using examples and a subsample of the data. The aim of this chapter is not to give a full analysis of the 2020 data, but to show what can be done with the data.
There are 36 different accident types present in the model and the differences between these accident types are substantial. Some types occur so infrequently that even with a full year of data the number of accidents is very small. This chapter focuses on one specific type of accident, namely where the victim is struck by a moving vehicle. Analyses of two other accident types were recently made available by the NLA in its annual report (Inspectie SZW, 2021).

4.1 The first year of data

In 2020, inspectors were asked to enter data on all the accidents that they had investigated that year, provided that the accident had occurred in 2020 and that the file was closed in that same year. As a result, MLfA data are available for 1,602 accidents in 2020. This is 73% of the approximately 2,200 reports that were completed in 2020. The remaining 27% mainly consists of accidents for which the files were completed in 2020 but that had occurred in earlier years.

In some cases a shortened version of the questionnaire was used – for example, when the accident was not formally reportable or if an accident could no longer be investigated after a late report – so that a total of 1,400 full questionnaires were submitted. Of these accidents approximately 35% resulted in a permanent injury or the death of the victim. For 53% of the accidents the victims' injuries were likely not to be permanent. For the remaining 12% of the accidents the final consequences for the victims were unknown to the inspector.

As discussed in Chapter 3, the MLfA is divided into 36 accident types. The 10 most common accident types in the 2020 data are shown in Figure 9. The most common type of accident reported by the inspectors is where the victim comes into contact with moving parts of a machine (230 accidents; 16.4%) followed by the accident type where the victim falls on the same level. Accidents where a victim is struck by a moving vehicle were the 5th most common type (82 accidents; 5.9%).

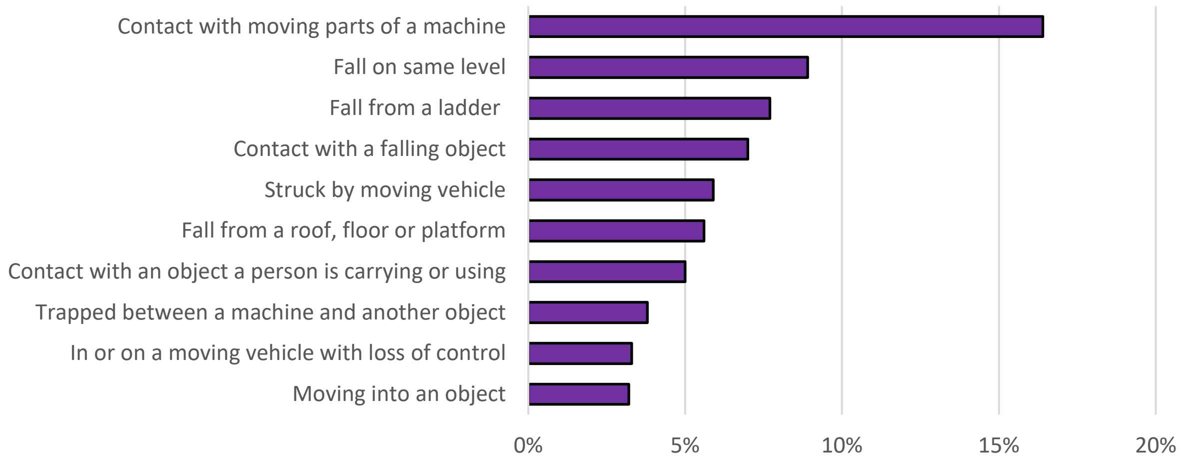


Figure 9 Most common accident types in the 2020 MLfA data

4.2 An example: struck by a moving vehicle

As an example of the type of data that is collected with the MLfA, we will provide detail from the 2020 data on the 82 serious accidents where a victim was struck by a moving vehicle or mobile machine. In this accident type, the victim is outside the vehicle, although the victim may in some cases be controlling it. Generally, these accidents have one victim; only one of the accidents that are reviewed in this chapter had two victims.

From earlier analyses of Storybuilder data[1] we know that these accidents can involve many different types of vehicles, most often forklift trucks but also lorries or diggers. This can also be seen in the 2020 data: forklift trucks were the most common vehicle type (60% was some type of forklift), followed by heavy goods vehicles (11%). Four of the accidents had fatal consequences (5%); permanent injury was likely for at least 20 further accidents. Most often, victims suffered broken bones (73%) and or wounds/superficial injuries (26%). These injuries commonly occurred on the leg(s) (35%), ankle(s), (26%) and/or feet (39%).

When a victim is struck by a moving vehicle, the way the victim was struck is relevant for the harm that is likely to occur. For this reason the main mechanisms that caused harm are assessed in the questionnaire; the relevant mechanisms and the extent to which they occur is shown in Figure 10. Note that the inspector could choose more than one answer. The figure shows that the mechanisms are quite diverse. Some victims were not just hit by a vehicle but were, for example, also caught between the vehicle and another object or dragged along by the vehicle.

[1] Basic analyses for all accident types within Storybuilder are available online at: https://www.lerenvoorveiligheid.nl/ (in Dutch).

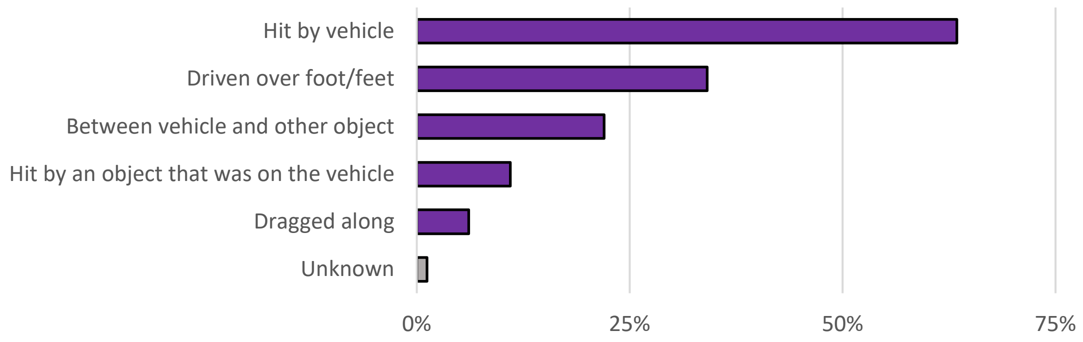


Figure 10 Mechanisms that caused harm
Figures are based on 82 accidents; more than one mechanism may be relevant and chosen for each accident

The events that occur (just) before the centre event are also captured in the MLfA questionnaire (see also Section 3.2.1). Figure 11 shows the events that occurred just before the victims in the 2020 data were struck by the moving vehicle.

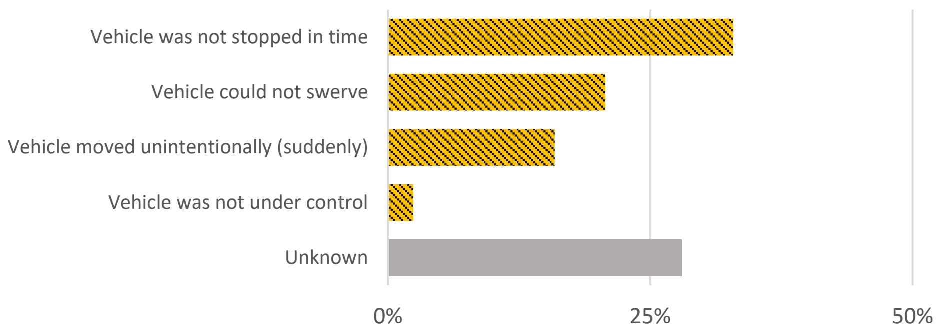


Figure 11 Example of the events just before an accident.
Based on an analysis of 82 accidents; if multiple mechanisms were relevant, the mechanism that occurred first was to be chosen by the inspector.

From figure 11 we can see that the vehicle was often not stopped in time or could not swerve to avoid the victim. To further understand why this happened the MLfA contains questions about 'what went wrong' or the safety barriers (see Section 3.3). Figure 12 shows what went wrong in these 82 accidents.

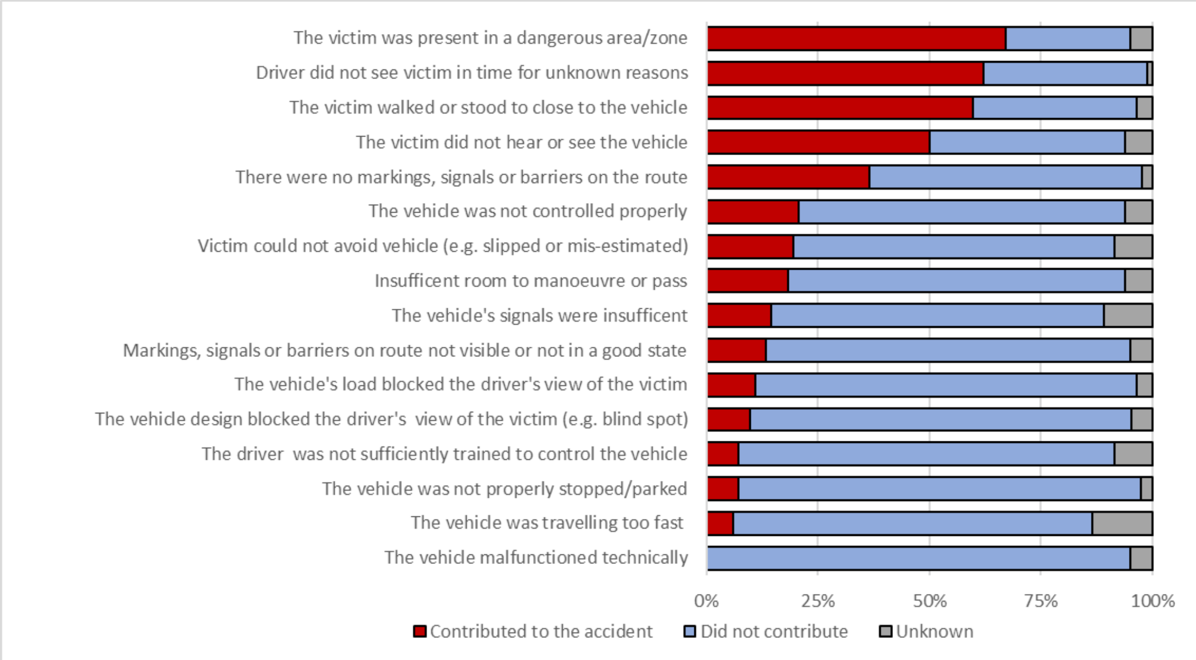
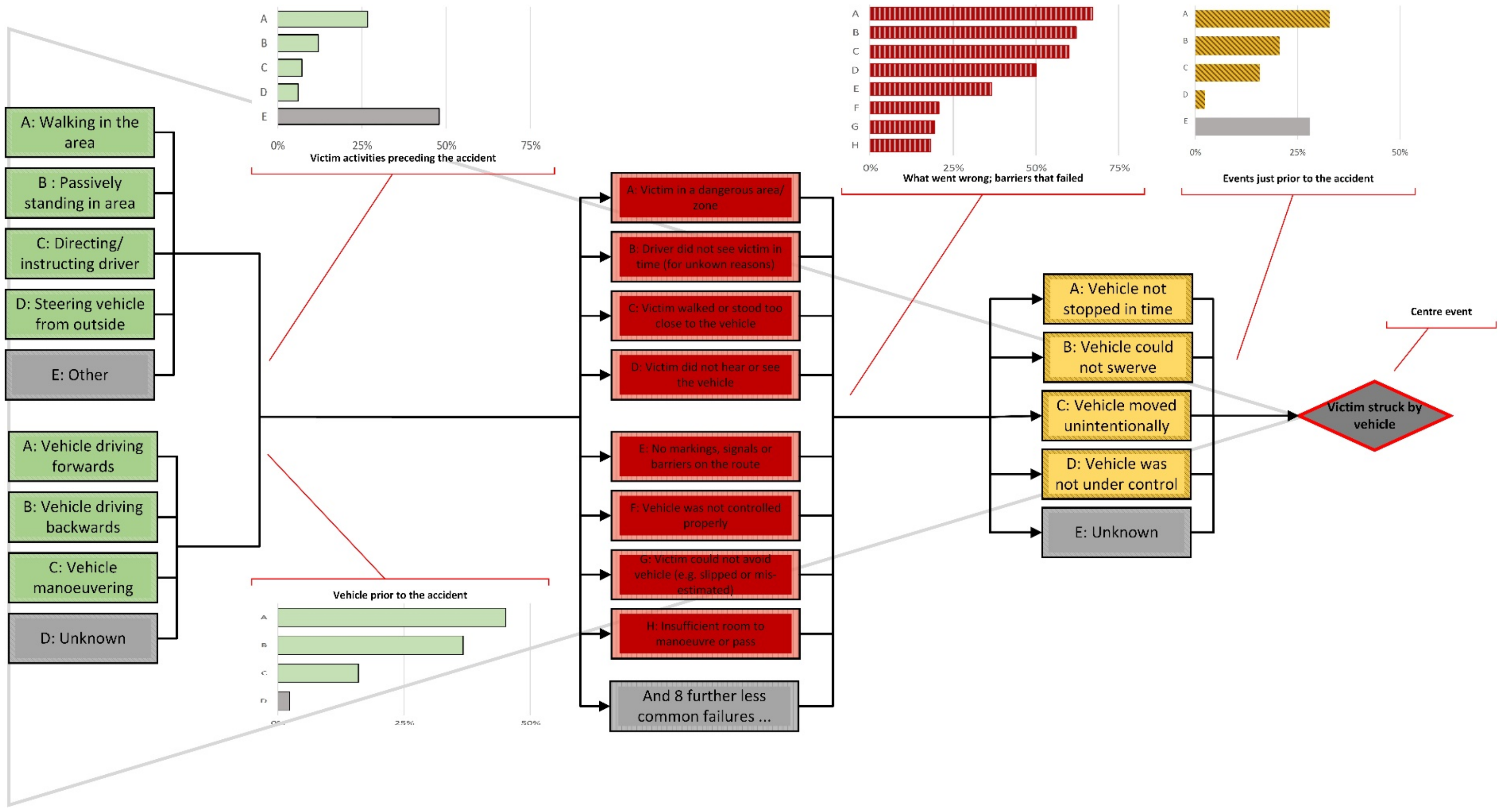


Figure 12 Example of what went wrong to contribute to the accident
Based on an analysis of 82 accidents; inspectors could choose multiple answers.

4.3 Depiction as a bowtie model

In the previous section we showed some data on the 82 serious occupational accidents where the victim was struck by a moving vehicle. To show how the different questions in the MLfA fit together we have developed a visualisation that summarises the main elements of the MLfA (bowtie-based) model (Figure 13, next page). This visualisation is just an example of the ways the data can be presented. It contains some simple graphs that show the frequencies of the activities and the failures and events that preceded the occupational accidents. This depiction of the data as a bowtie model refers back to the start of the project, the Storybuilder bowtie. In particular, it visualises how the data gathered in the MLfA relates to the (left side of) the classic bowtie model.



Based on an analysis of 82 accidents from 2020. The graphs show the frequencies of certain activities, failures and events that preceded these accidents.

4.4 Summary

In 2020 the first year of data for the MLfA was gathered at the labour inspectorate. In total 1,602 questionnaires were submitted in 2020. This chapter serves as an illustration of possible analyses using the MLfA data. Of the 36 available accident types, the most reported type was coming into contact with moving parts of a machine. This chapter has focused on one specific type of accident, where the victim is struck by a moving vehicle or mobile machine. There were 82 accidents of this type in the MLfA.

We have shown that information on the frequencies of the activities and events preceding the accidents, relevant failures, and the consequences of the accidents for the victims is readily available in the MLfA. The different questions fit together and can be visualised to show how the MLfA relates to the classical bowtie risk assessment model.

5 Conclusions and future development

5.1 Conclusions

The Storybuilder method, models and databases were developed by systematically analysing a large number of serious occupational accidents over many years. The Storybuilder models and the data have now been used to develop a new Monitoring System for Learning from Accidents (MLfA). With the MLfA a user-friendly questionnaire for use by labour inspectors was developed and successfully implemented within the Netherlands Labour Authority.

The goal of the system is to gather key information about serious occupational accidents and their main causes. The MLfA is used by all labour inspectors after investigating an occupational accident. Questionnaire items were adapted from the 36 Storybuilder models and underlying data in a systematic and uniform way. Care was taken to develop valid and user-friendly questionnaire items, which were refined through many iterative reviews. The inspectors who use the system were involved throughout the development of the questionnaire. A group of domain experts was also consulted regularly, and two pre-tests were conducted, one in person and one online. These tests showed that the MLfA instrument could be used to systematically capture much of the complexity of the occupational accidents that the inspectors investigate each day.

The MLfA was put into active use on 1 January 2020. Inspectors are asked to complete the questionnaire when they close the file on a specific accident. The system is used for all serious occupational accidents that are reported to the NLA. For 2020, data on 1,602 serious occupational accidents were gathered. The inspectors gave feedback on the MLfA during the first year, that feedback was generally positive. The data gathered with the MLfA can be used for various analyses to provide researchers, companies, policy makers and other stakeholders with the insights they need to help prevent future occupational accidents.

5.2 Future developments

The monitoring system has become an integral part of the work at the NLA. It is important that complete, consistent and relevant data are gathered in the coming years. The data can be used to report on and monitor occupational accidents in the Netherlands. Lessons can be shared with a wide audience in a similar way as is currently done with Storybuilder data: informing occupational safety professionals, employers and employees about accidents, their causes and potentially effective preventive measures. The data can also be used to help optimise the work of the labour inspectorate itself. Finally, researchers from RIVM and the labour inspectorate can in the future extend the monitoring system for a limited amount of time to help answer specific questions for research, policy, enforcement or practice.

Occupational accidents are diverse. Many different types of hazards can be relevant. This is why the MLfA includes separate questionnaires for many different types of accident, from common accident types such as a 'Fall from a ladder' or a 'Fall from a roof' to accident types that occur less frequently such as 'Contact with a hot surface' or 'Immersion/Drowning'.

The way we work – and therefore what it entails to work safely – is constantly evolving as new companies, technologies and business models appear. These new activities may impact the nature of occupational accidents and their causes. This complexity and diversity of occupational accidents and new developments make continual validation, maintenance and improvement of the MLfA necessary. RIVM recommends that the MLfA is continually and actively maintained; for example, by gathering feedback from inspectors and by regularly checking the data against other sources.

Finally, with some adaptations the MLfA method may help (larger) companies, industry bodies and other intermediary organisations (nationally and internationally) to systematically gather, organise and learn from information on their own serious occupational accidents.

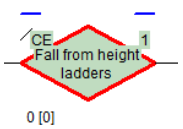
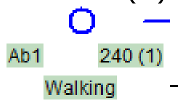
Appendix A List of accident types

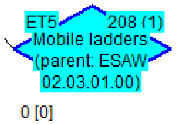
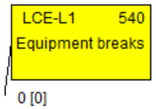
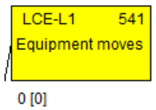
Storybuilder was developed with the following 36 accident types:

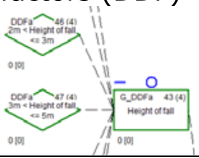
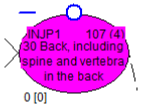
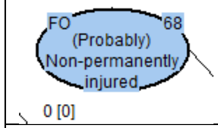
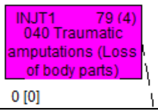
1. Fall from a ladder or stepladder
2. Fall from stairs or ramp
3. Fall from scaffolding
   This can be either fixed or mobile scaffolding.
4. Fall from a movable platform
   For example, cherry pickers, mast climbing platforms or the tailgate of a truck. A pallet or work tray on a forklift can also be a movable platform.
5. Fall from roof, floor or platform
   The victim has fallen from a roof, floor or a non-moving platform such as a balcony.
6. Fall from a non-moving vehicle
7. Fall into a hole in the ground
8. Fall from objects not intended to be climbed on
9. Fall on the same level
10. Hit by a falling object
    For example, tools that fall, parts of a building that break off, fall over or collapse.
11. Hit by a falling object during lifting operations
    For example, an object that fell from a crane or hoisting equipment.
12. Hit by a rolling or sliding object
13. Contact with a flying object
    This includes fragments of objects that (slowly) fall apart (such as splinters). The flying object can fly freely through the air, or it can still be attached to one side (such as a flying steel wire or hoses under pressure). The forces can be diverse, for example mechanical (tensile) tension, expansion, pressure, a moving machine, the wind, or throwing by a person.
14. Contact with hanging and/or swinging objects
15. Contact with object carried or used by someone
    Contact with an object the victim was handling himself or contact with an object that someone else was holding.
16. Contact with moving parts of a machine
    Hand tools not included.
17. Trapped between a machine and another object
18. Moving into an object
    Victim bumped into something or got caught on something.
19. Contact with hot or cold surface or open flames
20. Contact with hand tools, handled by the victim himself
21. Struck by moving vehicle
22. In or on moving vehicle with loss of control
    The victim was driving a vehicle or was driving along with a vehicle. For example, the victim falls from a moving vehicle or the vehicle itself crashes. It is also possible that the victim is partly on the vehicle (for example hanging from the vehicle).
23. Buried by bulk mass
    Such as dirt, a collapsing trench or the contents of a silo.
24. Immersion/drowning

25. Too rapid (de)compression
26. Contact with a hazardous substance without containment failure
    The victim came into contact with a hazardous substance or a hazardous atmosphere without this substance/atmosphere being released unintentionally. This means that there was no problem with the containment system.
27. Emission of a hazardous substance from a normally closed containment system
    A substance flows out of a system that is normally closed or that should be closed. The substance was released as a result of an accident.
28. Release of a hazardous substance from an open containment system
    The substance was released as a result of an accident (an undesirable combination of circumstances), for example by leaking, evaporating, spilling, splashing or overflowing.
29. Contact with a hazardous atmosphere in confined space
    The hazards that cause damage are inherent in the enclosed space and the conditions in that confined space (cold, heat, inhalation of harmful atmosphere/oxygen deficiency).
30. Contact with a hazardous atmosphere through breathing apparatus
31. Fire
    There was an unforeseen fire that led to the occupational accident.
32. Explosion
33. Contact with electricity
34. Extreme muscular exertion
35. Victim of human aggression
    Deliberate physical contact in which a person intentionally inflicted injury on the victim, e.g. biting, stabbing, kicking, shooting.
36. Contact with an animal
    This does not have to involve aggressive behaviour by an animal. Examples are falling from a horse, falling as a result of being pushed by a cow, getting caught between a bull and a fence, being stung by a wasp.

Appendix B Overview of variables adapted to the MLfA

Variable and original box	Role and relevance	The type of information that is captured (examples)	Adaptation to the MLfA
Centre event (CE) 	The centre event defines the moment at which control was lost over the main hazard. The centre event marks the transition from the preventive (left) side of the bowtie to the repressive (right) side of the bowtie.	1. The victim started falling from a ladder. 2. The victim was struck by a moving vehicle.	At the start of the MLfA questionnaire the centre event is determined by choosing the appropriate accident type (see Section 3.6).
Activities (A) 	Used to describe the activity or activities that preceded the accident. Also marks the start of the bowtie and the exposure of the victim to the risk of the centre event.	1. The victim was holding something in his hand whilst on the ladder. 2. The vehicle was being driven backwards.	Converted to a multiple-choice questionnaire item with pre-determined options (with the note to the respondent to choose the option that best describes the activity). Each accident type has a different activity question. For some accident types more than one activity is relevant. For some activities more than one questionnaire item is needed.

Variable and original box	**Role and relevance**	**The type of information that is captured (examples)**	**Adaptation to the MLfA**
Equipment type (ET) 	Used to record the (type of) equipment relevant to the accident. The type of equipment can vary widely, between as well as within accident types. A hierarchy of equipment types is used that is derived from the ESAW (*European Statistics on Accidents at Work (ESAW) — Summary methodology*, 2013). The equipment can have many roles in an accident: • equipment that the victim was using himself; • equipment that some other person was using; • equipment or part of equipment that fell.	1. The ladder that was used during the accident was a moveable one. 2. The vehicle that struck the victim was a small goods vehicle. 3. The object that fell during the accident was a brick.	Information on the type of equipment is gathered in one of two ways depending on the accident type: A. A multiple-choice questionnaire item with a small number of pre-determined options; B. A text lookup interface with pre-determined options. Option A is preferred when only a few well defined options are relevant for the accident type. Option B is used when there is more diversity in the equipment types. If the inspector cannot find the relevant equipment type in the pre-determined answers, they can provide a response in free text. If the inspector feels that more details about the equipment type are needed, they can also provide a response in free text.
Loss of control event (LCE)  	Essential steps in the chain of events that led to the accident or that came after the accident. There may be multiple steps before an accident.	1. The ladder slipped away. 2. The vehicle started moving suddenly and unintentionally.	Converted to a multiple-choice questionnaire item with pre-determined options for each accident type (with a note to the respondent to choose the one that happened first). Only loss of control events that precede the accident are adapted for the MLfA. For most accident types one question is used. For some accident types no question about the LCE is asked.

Variable and original box	Role and relevance	The type of information that is captured (examples)	Adaptation to the MLfA
Dose-determining factors (DDF) 	Factors that influence the severity of the consequences of the centre event. They are used to quantify the amount of hazardous energy that struck the victim.	1. The victim fell from a height of approximately 5–10 metres. 2. The victim was dragged along by the vehicle after being struck.	Converted to a multiple-choice questionnaire item with pre-determined options. DDFs are linked to a subset of accident types (see Part C). Height of fall, for example, is relevant to 8 of the 36 accident types.
Part of the body that was injured (INJP) 	Indicates the part of the body that was injured in the accident. Uses the European ESAW classification system.	1. The victim sustained injury to the head. 2. The victim sustained injury to the fingers.	Converted to a questionnaire item with pre-determined options. It is possible that the victim sustained more than one injury; the inspector can choose all options that apply.
The final outcome for the victim (FO) 	A group of boxes used to indicate the consequences of the accident for the victim.	1. The victim died as a result of the accident. 2. The victim sustained injury likely to be permanent.	Converted to multiple-choice questionnaire item with pre-determined options. Used for all accident types.
The type of injury sustained (INJT) 	Indicates the type of injury sustained by the victim. Uses the ESAW classification system.	1. The victim sustained a traumatic amputation. 2. The victim drowned or asphyxiated.	Converted to a questionnaire item with pre-determined options. It is possible that the victim sustained more than one injury; the inspector can choose all options that apply.

Variable and original box	**Role and relevance**	**The type of information that is captured (examples)**	**Adaptation to the MLfA**
The failure (BFM) or success (BSM) of barriers (B) and details (IF). 	Barriers are safety measures that (could) prevent or moderate the causal chain. See Section 3.3 for details.	1. The ladder was placed incorrectly. 2. The infrastructure at the workplace was insufficient.	Adapted together with the incident factors into a group of multiple-choice questions 'What went wrong?' (see Section 3.3). For each question there are three response options: 1. This contributed to the accident; 2. This did not contribute to the accident or it is not applicable; and 3. Do not know

Appendix C Annotated example questionnaire

This version of the questionnaire is presented to the user after he or she has provided some basic information such as the number of victims. Furthermore the inspector has by this point already indicated that a fall from a scaffold was the centre event (see section B in Figure 8). The further questions build upon this premise. Table 6 shows the questions that are asked for this accident type (see section C in Figure 8). The table includes a short comment on the logic or routing for each specific question or text field.

Table 6 example questionnaire fall from scaffold (Questions specific to the accident type, section C)

Q#	Question or text field	Response options	Comment on logic or routing
	Fall from scaffold A victim was injured after falling from a scaffold. This accident type addresses accidents with both fixed scaffolding and mobile or rolling scaffolds. Both types of scaffolding are referred to as scaffolds in the remainder of this questionnaire. **Similar but different** The accident type listed below is (slightly) different and needs to be entered with a different set of questions. If you wish to enter this accident type, please click 'Previous'. • If the victim fell from a so-called 'lifting scaffold' or 'scissor lift', choose the subtype: 'Fall from a lifting scaffold'. If you have doubts about the accident type, you can also contact the project team. *Do you want to use this accident type for the further analysis of the accident?*	The respondent can at this stage: • continue the analysis with this accident type, • choose a different accident type, or • choose to ask for help via a dedicated email address.	The respondent has already chosen the accident type 'Fall from scaffolding'. However, ensuring that the correct accident type is chosen is considered very important. Therefore, this section allows inspectors to verify their choice or to ask for help if they need it.

Q#	Question or text field	Response options	Comment on logic or routing
1	Did the victim fall from a fixed scaffold or from a mobile scaffold?	• Mobile scaffold (ESAW 02.03.03.00) • Fixed scaffold (Part of: ESAW 02.04.01.00) • Other (different) type of scaffold • Unknown	This question addresses the type of equipment used. A multiple-choice questionnaire item could be used for this accident type (see Appendix B). Inspectors are required to select (at most) one option.
2	If desired, provide a specific description of the work equipment.	Open question	Only shown if the answer to question 1 was not ‘unknown’
3	What was the victim doing on the scaffold?	• Going up (climbing) • Descending • Working at height • Installing the scaffold • Dismantling the scaffold • Unknown	Based on a group of boxes related to the victim activity (see Appendix B). For this accident type three separate questions (numbers 3, 4 and 5) are used to encode the victim’s activity.
4	Was the victim holding an object while climbing or descending?	• Yes • No • Unknown	Only shown if the answer to question 3 was ‘going up’ or ‘descending’
5	What work did the victim do whilst on the scaffold? *Choose that which best describes the victim’s activities.*	• Working with mechanised hand tools • Working with non-mechanised hand tools • Painting • Inspecting • Adjusting • Measuring • Cleaning • Installing or disassembling • Being present on the scaffold while the scaffold is being moved • Unknown • Other	Only shown if the answer to question 3 was ‘working at height’

Q#	Question or text field	Response options	Comment on logic or routing
6	Who installed the scaffold?	• Installed by the user or a direct colleague • Installed by the victim’s company • Installed by another company/third party • Unknown	

Q#	Question or text field	Response options	Comment on logic or routing
	What went wrong? The following questions address what went wrong and contributed to the accident. For each item on the list below please indicate whether it contributed to the accident. One accident can have multiple (contributing) causes.		Respondents are required to assess each individual item on the list separately. The design of these questions is extensively discussed in Section 3.3.
7	The edge protection was not present.	For each item: • Contributed to the accident • Did not contribute/not applicable • Do not know	
8	The edge protection was incomplete.		
9	The edge protection was defective.		
10	The edge protection had been (temporarily) removed.		
11	The scaffold was not properly constructed.		
12	The floor of the scaffold was in a poor state.		
13	The scaffold had been placed on or against an unsuitable surface.		
14	The scaffold was placed in an area that was not protected against external forces (e.g. protected against collision with a vehicle or bumping by a hoisted load).		
15	The scaffold was not properly anchored.		
16	The stabilisers for the scaffold had not been deployed.		
17	The brakes for the scaffold had not been engaged.		
18	The victim was climbing or hanging on the outside of the scaffold.		
19	The victim slipped or tripped.		
20	The victim lost his or her balance for unknown reasons.		

Q#	Question or text field	Response options	Comment on logic or routing
21	How did the victim fall from the scaffold? *Choose what happened first.*	• The scaffold fell over • The scaffold moved suddenly • The victim lost his or her balance (scaffold remained standing) • The scaffold collapsed • The scaffold broke • Unknown	
22	How many metres did the victim fall?	• Less than 1 metre • 1 to 2.5 metres • 2.5 to 5 metres • 5 to 10 metres • More than 10 metres • Unknown	
23	Did the victim fall on a hard or on a soft surface?	• A soft surface (e.g. grass or mud) • A hard surface (e.g. stone or concrete) • Unknown	
24	Did the victim fall on an object?	• Yes, on an object that was on the ground • Yes, on an object that fell with the victim • No • Unknown	
25	Did the victim use personal fall protection (e.g. a harness)?	• Yes • No, but this was required for the work • No, and this was not required for the work • Unknown	
26	Did the personal fall protection function properly?	• Yes, injuries were (partly) prevented • No, measures were not applied properly • No, measures did not work properly • Unknown	If the answer to question 25 was 'yes'.

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