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Analysis of Fall-Related Imminent Danger Orders in the Metal/Nonmetal Mining Sector

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Abstract

Within the metal/nonmetal mining sector, fall-related incidents account for a large proportion of fatal and non-fatal injuries. However, the events and contributing factors leading up to these incidents have not been fully investigated. To help provide a clearer picture of these factors, an analysis of imminent danger orders issued by the Mine Safety and Health Administration (MSHA) between 2010 and 2017 at both surface and underground metal/nonmetal mine sites revealed that most orders are associated with fall risks. Of these cases, 84% involved the workers not using fall protection, fall protection not being provided, or the improper use of fall protection. Fall risks for workers most frequently occurred when standing on mobile equipment, performing maintenance and repairs on plant equipment, or working near highwalls. In most cases, a single, basic, corrective action (e.g., using fall protection) would have allowed workers to perform the task safely. Overall, these findings suggest that a systematic approach is needed to identify, eliminate, and prevent imminent danger situations. Furthermore, to protect mineworkers from falls from height, frequently performed tasks requiring fall protection should be redesigned to eliminate the reliance on personal fall protection.

Keywords

Imminent danger; Hazard recognition; Fall injuries; Fall prevention

1 Introduction

Mines are a dynamic environment where workers are tasked with performing diverse work activities using a variety of tools and equipment [1]. As a consequence, mineworkers carry out their duties in a relatively hazardous environment as compared with other industries and are often faced with dangerous situations that have a high potential for severe or even fatal injury [2]. This is especially true for mineworkers who are exposed to fall-related hazards.

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Working at height is very common at mine sites, especially metal/nonmetal sites, due to the design of mine equipment and machinery, the presence of highwalls, the size of equipment used, and activities such as machine maintenance and repair. Falls are a significant cause of fatal injuries and are the second leading cause of non-fatal injuries at mine sites [3]. The classification of “slip or fall of person” accounted for 55 (11%) of the 479 fatal injuries at mines between 2006 and 2015 [4]. Nearly 60% of all slip or fall fatal injuries could be attributed to falls from height. Most of the fatal injuries occurred due to a mineworker falling through an opening, failure of the floor or equipment, being ejected or thrown from equipment, or unexpected movement. In nearly one-third of the fatal fall incidents, the appropriate use of fall protection could have prevented the incident [4]. In addition, providing adequate barriers, inspecting equipment, and providing safe operating procedures may have prevented the remaining fatal injuries.

When fall injuries occur, mine operators are required to report these events to the Mine Safety and Health Administration (MSHA) [5]. As the regulatory agency for the mining sector, MSHA maintains records on all accidents, injuries, and illness and has the authority to issue citations and orders to mine operators in violation of federal regulations. Non-fatal incidents are reported to MSHA by mine operators; however, when a fatal injury occurs, MSHA conducts a full accident investigation to determine the root causes of the fatality and to provide recommendations to prevent future occurrences. MSHA also conducts periodic inspections of all active mine sites in the USA and issues citations for noncompliance with federal mine safety regulations [6]. Additionally, to protect mineworkers from high-risk situations that could lead to serious injury or death, MSHA has the authority to issue imminent danger orders at any mine site located within the USA. Once issued, an imminent danger order serves as an immediate stop or withdrawal order from an unsafe activity or location respectively in a mine site until MSHA can determine the danger has been removed. Records of all injuries, citations, and orders are made publically available.

1.1 Analysis of Fall-Related Imminent Danger Orders

While there is something to learn from each incident, the primary issue with examining non-fatal fall injury reports is that there is typically limited information. Often, the narrative description of the conditions contributing to the fall in non-fatal injury reports is brief in nature as they are self-reported by mine operators and contractors required to file a Mine Accident, Injury, and Illness Report (MSHA form 7000–1) for each incident [5]. Similarly, when reviewing fatal fall reports, it is not always possible to determine exactly where the mineworker was working, what specific activities led up to the fall, what caused the fall, or why the activity performed differed from the expected “safe” operation [7]. However, imminent danger orders can provide insight on the activities that occur prior to a potential fall and help build a clearer picture of how serious or fatal falls can occur.

The Federal Mine Safety & Health Act of 1977 [6], also known as the Mine Act, defines imminent danger as “the existence of any condition or practice in a coal or other mine which could reasonably be expected to cause death or serious physical harm before such condition or practice can be abated.” When imminently dangerous situations occur, MSHA can issue imminent danger orders to immediately remove mineworkers from exposure to serious

hazards and to prevent them from entering or re-entering hazardous areas. Once issued, an imminent danger order serves as an immediate withdrawal order from the adverse condition and may cover an affected service area, equipment, or activity. Orders may be issued verbally in person or over the phone if MSHA receives a hazard complaint; however, they are not applicable to an accident or incident that has already occurred. Imminent danger orders are typically issued verbally first, then made into written orders that clearly identify the imminent danger situation. The orders, written by MSHA inspectors, must include the person to whom the order was issued, the time and date when the order was issued, a short descriptive narrative of the hazardous conditions that constitute imminent danger, and a description of the area where mineworkers were withdrawn from and are prohibited from entering or re-entering (Federal Mine Safety & Health Act of 1977 section 107 (c)). MSHA maintains records of all imminent danger orders that are issued under the Mine Act [6].

Given that fall incidents and injuries continue to be a significant problem for the mining industry, the purpose of this research is to examine MSHA imminent danger orders associated with potential falls at metal/nonmetal mine sites. An in-depth analysis of imminent danger data may reveal additional information that will lead to recommendations to prevent fall accidents and injuries. Imminent danger orders provide a unique opportunity to better characterize a potentially serious or fatal fall scenario before a fall occurs and determine what safety measures were not being implemented and why. By analyzing the narratives of imminent danger orders issued by MSHA inspectors between 2010 and 2017, this paper aims to identify the most common fall-related imminent danger situations, what safety procedures are necessary that are not being followed, where these imminent danger situations are occurring, and, finally, provide recommendations based on the current literature about how to prevent imminent danger situations at mine sites.

2 Methods

2.1 Selection of Fall-Related Imminent Danger Orders

From 2010 through 2017, 1999 imminent danger orders were issued by MSHA at surface and underground metal/nonmetal mine sites [8]. Of the 1999 orders, 1793 (90%) were issued at surface mine sites, and the remaining 206 (10%) orders were issued at underground mine sites. The publicly available dataset of imminent danger orders contained details of each order (such as the person to whom the order was issued, the time and date when the order was issued, and a short descriptive narrative written by the MSHA inspector of the adverse conditions that constitute imminent danger); however, it does not classify the orders by the type of potential incident. In order to select fall-related imminent danger orders, two of the researchers (JPP and LMK) developed a classification system based on MSHA “Classification of Mine Accidents” definitions [9] to categorize each order. MSHA “Classification of Mine Accidents” definitions are normally used during the course of an accident investigation to identify the circumstance that most directly contributes to a resulting accident. However, for this study, NIOSH researchers used the “Classification of Mine Accidents” definitions to identify the circumstance that mostly contributed to the issuance of the imminent danger order.

All of the imminent danger order narratives were manually coded independently by two of the researchers (JPP and LMK). After completing the coding, the researchers reviewed their coding together and reached a consensus for all differences. Over half (50.4%) of the imminent danger orders reviewed were categorized into the classification of “Slip or fall of person” (Table 1). MSHA’s definition of “Slip or fall of person” includes slips or falls from an elevated position or at the same level while getting on or off machinery or haulage equipment that is not moving. It also includes slips or falls while servicing or repairing equipment or machinery and includes stepping in a hole [9]. A detailed look at imminent danger orders classified as “slip or fall of person” indicated that all imminent danger orders were exclusively related to falls (referred to as Fall-related Imminent Danger Orders from here on) and were selected as for further analysis in a two-phase process.

2.2 Phase 1 Coding of Fall-Related Imminent Danger Orders

Two researchers (JKH and BME) independently coded the fall-related imminent danger orders to determine the complexity of the situations using Eiter and colleagues’ [10] definitions. The orders were categorized as “Procedural” if the imminent danger situation had one clear safety procedure that was needed to safely perform the work task. These are the least complex of the imminent danger situations. “Complex” are situations where more than one safety procedure or more than one corrective action is needed to safely perform a work task. For example, a worker performing a maintenance task on the beltline has to first de-energize and lock-out/tag-out the power source and then tie off at the work location when working at height. The third category, “Specialized,” are situations that may have been avoided had the mineworker had domain-specific knowledge about a task or location at a mine site. For example, mineworkers operating equipment at the highwall are better able to recognize imminent danger situations if they have knowledge of the geology of the rock they are mining. After independent coding was complete, the researchers compared coding and were able to reach a consensus for all differences.

2.3 Phase 2 Coding of Fall-Related Imminent Danger Orders

Two researchers (JPP and LMK) developed a coding scheme (Table 2) to determine the primary and secondary reasons (factors) for issuing the imminent danger order, the working surface (location) of the order, the activity being conducted at the time of the order, the exposed fall distance (when available), and the employment type (mineworker, contractor, customer/delivery, or mine management) of the person involved (when available). These researchers independently coded the orders and used a third researcher (MFN) to assist with reaching consensus on all discrepancies. The primary factors for the fall-related orders were broken into five distinct categories, as detailed in Table 2: fall protection, safe access, unsafe conditions, unsafe act, and inadequate barricades, guarding, or signage.

The activity being conducted at the time of the order was coded in accord with MSHA’s classification of activity reference [9]. Additional categories were added for some common activities identified in the imminent danger orders that would otherwise be classified as “Other, Not Elsewhere Classified (NEC)” based on the MSHA’s classification. The working surface and the exposed fall distance were also recorded when this information was provided within the text of the order. Finally, when available, the employment type of the person in

the imminent danger order was coded as “mineworker,” “contractor,” “customer/delivery,” “mine management,” or “unknown.” Mineworkers were individuals identified as being mine employees. Contractors were individuals who worked for a contractor of the mine company. Customer/delivery was individuals that were customers of the site, delivery personnel, or any other personnel that were not mine employees or contractors. Mine management was mine employees in managerial positions such as foreman, supervisor, superintendent, or owner. When the employment type could not be determined, it was coded as “unknown.”

2.4 Common Work Situations for Fall-Related Imminent Danger Orders

The data were further categorized and grouped in phase 2 coding to determine if certain combinations of the available data would reveal situations in which fall-related imminent danger orders occur. Initial coding determined the most common work surfaces attributed to imminent danger. These work surfaces were then grouped with the most common reference activity and height above ground at the time of the imminent danger order being issued to further classify the data into three work situations: working on a truck, working in a plant area, and working near a highwall.

3 Results

3.1 Situational Complexity

Phase 1 coding revealed that a large majority of the fall-related imminent danger situations (82.7%) were found to be the least complex and had the “Procedural” classification (Table 3). In these cases, one safety procedure that should have been taken while performing the task was omitted. In contrast, a relatively small portion (16.8%) of the cases were classified as “complex” situations where more than one safety procedure or more than one corrective action was needed to safely perform a work task. “Specialized” situations that required a worker to have domain-specific knowledge of a problem represented an even smaller (less than 1%) portion of the fall-related imminent danger orders.

3.2 Primary and Secondary Factors

Phase 2 coding revealed that fall protection was the primary factor to the fall-related imminent danger orders and was usually due to a worker not using fall protection, as shown in Table 3. Workers who were wearing fall protection but were not tied off, along with the other classifications of “not provided,” “improper use,” “no tie-off location,” and “unsafe for use” made up a small proportion of the cases, together accounting for 12% of the total cases.

Primary factors other than fall protection that accounted for a sizeable portion of the data include “safe access” and “unsafe acts.” In some cases (7.7%), safe access was not provided for use, and in 6.2% of the cases, the worker was performing an unsafe act. The primary factors of “inadequate barricades, guarding, or signage” and “unsafe condition” made up a small proportion of the data with each accounting for 1% or less of the cases. On occasion, cases were coded into two categories when the narrative described a situation with multiple primary factors. For example, some cases fit the criteria for “fall protection” and “safe access.” These cases were counted twice and are accounted for in the note below Table 3.

3.3 Common Work Situations for Fall-Related Imminent Danger Orders

The top five work surfaces (shown in Fig. 1) attributed to fall-related imminent danger orders were truck, conveyor, screen, crusher, and highwall. These work surfaces were grouped based on the type of work and location into three common work situations: working on a truck, working in a plant area, and working near a highwall. Details of activities commonly performed in those work situations, and related primary factors and work heights, are described below.

3.3.1 Working on a Truck—Twenty-nine percent of fall-related imminent danger orders involved workers on a truck. Of these cases, the largest portion of imminent danger orders occurred when workers were performing the activity of tarping (covering the top of a truck bed with a tarp to prevent a loose material from blowing, falling, or spilling out of the vehicle) or opening/closing a hatch on a truck (Table 4). Other activities such as hand loading/shoveling, leveling load, cleanup, and machine maintenance and repair were also common. For all of the top work activities, fall protection was the primary factor for the imminent danger order. The majority of the cases on a truck were at a reported height of 5 to 10 ft above ground.

3.3.2 Working in a Plant Area—Equipment and machines typically found in a plant setting, such as conveyors, screens, and crushers, were among the top five work surfaces and accounted for 15%, 8%, and 6% of cases, respectively. The largest portion of imminent danger cases for each of these work surfaces occurred when workers were performing the activity of maintenance and repair (Tables 5, 6, and 7). Fall protection again was the primary factor for the imminent danger orders when the work surface was a conveyor, screen, or crusher. The predominantly reported working height was 5 to 10 ft above ground for conveyors and 5 and 15 ft above ground for screens and crushers.

3.3.3 Working Near a Highwall—The work surface of highwall accounted for 6% of the imminent danger orders. The largest portion of these cases occurred when workers were performing the activities of drilling and blasting (Table 8). Fall protection was again the primary factor when the work surface was a highwall. The reported height for these cases was predominantly above 15 ft.

3.4 Employment Type

The data were also categorized in phase 2 coding to determine the employment type of the person involved in the imminent danger situation (Fig. 2). Mineworkers accounted for 66% of the cases, while contractor and customer/delivery accounted for 15% and 12%, respectively. Four percent of cases involved a member of mine management or where a member of mine management was present. Three percent of the cases could not be coded due to limited information in the narrative description.

4 Discussion

The intent of this research was to categorize fall-related imminent danger situations and better understand events that could lead to serious or fatal injury. This analysis sheds light on

imminent danger situations by first looking at the complexity level of the situations, followed by the primary factors and secondary factors involved, and, finally, identifying the most common imminent danger situations. Recommendations based on the current literature for each of these situations are provided.

4.1 Situational Complexity

Phase 1 of the analysis revealed that most fall-related imminent danger orders are issued when one necessary “Procedural” step that should have been taken to perform the task safely was omitted—mainly, the use of fall protection when working at heights. Eiter and colleagues [10] determined that imminent danger situations vary in their level of complexity, which can have implications for preparing mineworkers to identify and respond to these situations. For the majority of the fall-related cases in our analysis, the use of a single, basic, corrective action may have allowed the worker to perform the task safely. This finding was similar to that found in an analysis of fatal incidents in mining [11].

From the data, it is not clear why procedural controls are not used. However, Eiter and colleagues [12] suggest that one potential reason is that mineworkers report becoming complacent while performing routine tasks. Some of these routine tasks could include maintenance and repair, leveling loads on trucks, or loading blast holes identified in this analysis. In these routine situations, it is important for supervisors and safety professionals to provide timely and immediate feedback to mineworkers (e.g., communicating the value of fall protection and building a bigger picture of risks of the job) [13].

4.2 Primary and Secondary Factors

In terms of contributing factors leading to fall-related imminent danger situations, this analysis found that half of all imminent danger orders issued by MSHA between 2010 and 2017 were associated with slip or fall of person hazards; of those, most involved the lack of or inappropriate use of fall protection when working at heights. Working at heights without fall protection is a significant problem in the mining industry and contributes to 33% of fall-related fatalities [7]. The high prevalence of fall-related injuries and fatalities may be due to the design of mining facilities and the nature of the work, where many activities require workers to stand atop elevated structures for routine activities. Two main approaches mine operators can take to address these incidents include providing a safe work environment by using a systems approach to look at the design of the work environment to reduce the presence of fall hazards or facilitate the use of fall protection and provide training to increase the use and adoption of fall protection.

First, as our analysis revealed, in over 12% of the orders issued by MSHA inspectors, the narrative described a situation in which mine operators failed to provide a safe working environment. These were incidents where no safe access was provided to an area or fall protection was not available. Nelson and colleagues [14] proposed that employers may not comply with safety standards because regulatory requirements may be difficult to understand, implement, or carry out on an ongoing basis or are perceived as being too costly. Additionally, the authors suggested that with a low likelihood of inspection, the burden of implementing workplace safety measures may out-weigh the potential cost and risk of

inspection and citation. While the addition of permanent, fixed-access systems to infrequently accessed locations may create high financial burden to mine operators, portable access systems such as extension ladders, and personal fall arrest systems are very inexpensive means of ensuring that safe access is provided and that workplace safety measures are readily available to mineworkers. Without safe access or safety measures, workers may not have a safe way to conduct their required work activities. This applies to both mine employees and non-mine personnel who conduct work activities at mine sites. Mining contractors have been previously found to be nearly three times more likely to sustain a fatal versus non-fatal injury when compared with mine employees [15]. In the current analysis, contractors and non-mining personnel such as delivery workers or customers made up over one-fourth of the imminent danger orders at mining facilities. Providing built-in systems and safeguards where workers are not forced to rely upon a personal fall arrest system may improve safety for both mining and non-mining personnel.

The development of effective countermeasures to prevent falls must be based on a comprehensive framework that includes the design of the work environment, decision processes of the workers, and factors such as the organizational and team culture [16]. Slips, trips, and falls, especially, demand a systematic problem-solving approach that includes the identification and elimination of unsafe conditions, at-risk behaviors, and unsafe acts [17]. This analysis revealed that imminent danger orders issued at mine sites include all of these factors, with unsafe conditions including working at heights and where there is a danger of falling or where safe access is not provided, at-risk behaviors including wearing fall arrest harnesses and not being tied off, and unsafe acts including not using provided safe access systems.

Secondly, our analysis revealed that 74% of imminent danger orders involved the lack of fall protection. While fall protection use in mining has not been thoroughly researched, the lack of fall protection usage has been extensively researched in the construction industry. Proactive methods such as education and training have been found to reduce serious falls from height, and reducing the duration of time working at heights can reduce the severity of falls from heights [18]. Cattledge and colleagues [19] provided four recommendations to improve the adoption of personal fall protection:

1. Employers need to include fall protection in their health and safety program.
2. The quality of fall protection training should be improved and include what personal protective equipment to use, how to use it, and when to use it.
3. Employers should provide and reinforce the use of fall protection.
4. Research and development of fall protection is needed for environments where fall protection is difficult to adapt.

4.3 Common Work Situations for Fall-Related Imminent Danger Orders

4.3.1 Working on a Truck—Trucks were the most common work surface, with tarping/closing hatches, hand shoveling/mucking, and leveling load being common activities conducted at the time of the imminent danger order. Trucking has previously been associated with slips, trips, and falls due to activities such as manually adjusting tarps [20]. Customer

and delivery trucks at mines are common, especially when material is transported via road. Twelve percent of the imminent danger orders were attributed to customer/delivery employees, many of which included truck drivers working at an unsafe height on top of their truck. Tarping and closing hatches on trucks to prevent the contamination or spillage of the material are common tasks. The large proportion of imminent danger orders associated with this task indicate that this is a very common situation for both mineworkers and customer truck drivers. From the data, it is unclear why mineworker and customer truck drivers are choosing to work at heights without fall protection. It may be that they either do not adequately recognize the risk associated with this common task or that adequate solutions to minimize or eliminate the hazard are not implemented or used.

Hand shoveling/mucking and leveling loads on trucks could be attributed to quality control issues related to the truck being overloaded or improperly loaded (unbalanced), which then requires the additional activities of leveling and removing excess material. Unless access platforms are provided, truck drivers are forced to stand atop their loaded truck to address these quality control issues. Consideration of the entire load-out process including implementing quality controls for loading and safe access for tarping, closing hatches, and leveling loads when needed may help to eliminate these types of fall hazard.

4.3.2 Working in a Plant Area—Conveyors, screens, and crushers were the second, third, and fourth most common surfaces associated with imminent danger orders. When these findings were cross-tabulated with activity, the most common activity for these surfaces included maintenance and repair and hand shoveling. Falls from height is a significant contributor to fatal injuries during maintenance and repair [13]. Maintenance and repair, and especially installation and dismantling tasks, are often complex activities that can result in the introduction of new fall hazards that did not exist at the beginning of the maintenance activity.

To help address this issue, mineworkers should be encouraged to perform a hazard assessment before work begins and then re-examine their work area as work activities progress. Additionally, the development of standard operating procedures by the organization for each maintenance task may help to identify the safest and most efficient way to perform a task and ensure necessary controls and that personal protective equipment is provided and readily available. Maintenance workers are encouraged to use personal fall protection for any work not occurring on the ground level. These recommendations would also address some of the key contributing factors to fatal falls previously identified [11]. However, it is unclear from the data why mineworkers are not using fall protection. Further analysis of mineworkers' risk perception in these situations could reveal why fall protection was not used and allow for more specific recommendations on how to increase the use of fall protection systems.

4.3.3 Working Near a Highwall—The fifth most common work surface associated with fall-related imminent danger orders was the highwall. The most frequent activities at the highwall include drilling, blasting, and handling supplies or material. Many of these cases involve workers conducting activities near the crest of a highwall with a significant fall distance of greater than 15 ft. In these cases, the crest of the highwall was not sufficiently

bermed or barricaded off, and the worker was not using fall protection. Again, it is unclear why fall protection was not used in these cases. Mineworkers should be provided with safe working procedures and adequate training to ensure proper precautions are taken when working near highwalls. This could include planning for adequate bench width to allow for safe access and the construction of safety berms along the crest of the highwall.

5 Limitations

The results of this analysis are based on imminent danger order narratives written by MSHA inspectors at the time of the incident. MSHA inspections do not occur every day at all mine sites, and no additional steps were taken by NIOSH researchers to investigate the nature of the incidents. With regard to identification of imminent danger situations, there is likely to be variability between inspectors, regions, or districts. It may be that the high number of fall-related orders is due to heightened focus on these types of incidences through training, district-specific initiatives, or other policies. Additionally, the narrative data does not give us adequate information to determine why imminent danger situations are occurring. Further analysis may allow researchers to gain the perspective of those involved in imminent danger situations and determine the limitations and barriers to use for existing fall protection systems.

6 Conclusions

Analysis of fall-related imminent danger orders issued by MSHA between 2010 and 2017 revealed that the majority of fall-related orders involve the incorrect use or absence of fall protection. In most cases, only one corrective action (using fall protection) may have allowed the worker to perform the task safely. These cases occurred on various work surfaces throughout the mine including trucks, plant equipment, and highwalls. In many of these cases, consideration of the workplace design may help to eliminate the need for fall protection or to eliminate the risk. Truck drivers, for example, should not have to put themselves in fall-from-height situations to remove excess materials due to poor loading practices. Moreover, providing tarping or hatching stations may eliminate the need for fall protection when tarping a load or opening and closing hatches.

While these findings indicate that not using fall protection is a significant problem in the mining industry, the results do not offer an explanation for why mineworkers are choosing not to use fall protection when it is provided. Further analysis of imminent danger situations and mineworkers' perceptions of the risks associated with these situations could reveal why fall protection was not used or deemed not necessary in these cases.

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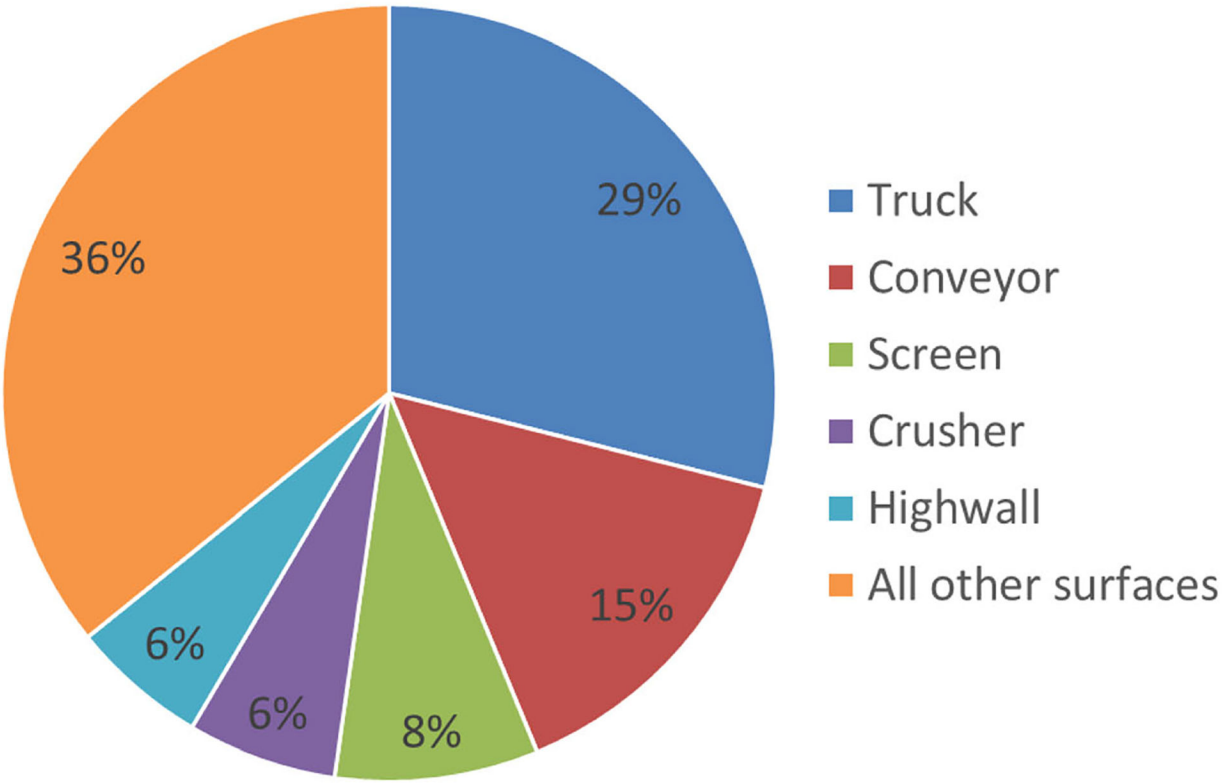

Fig. 1.
Top five working surfaces for fall-related metal/nonmetal imminent danger orders issued by MSHA between 2010 and 2017

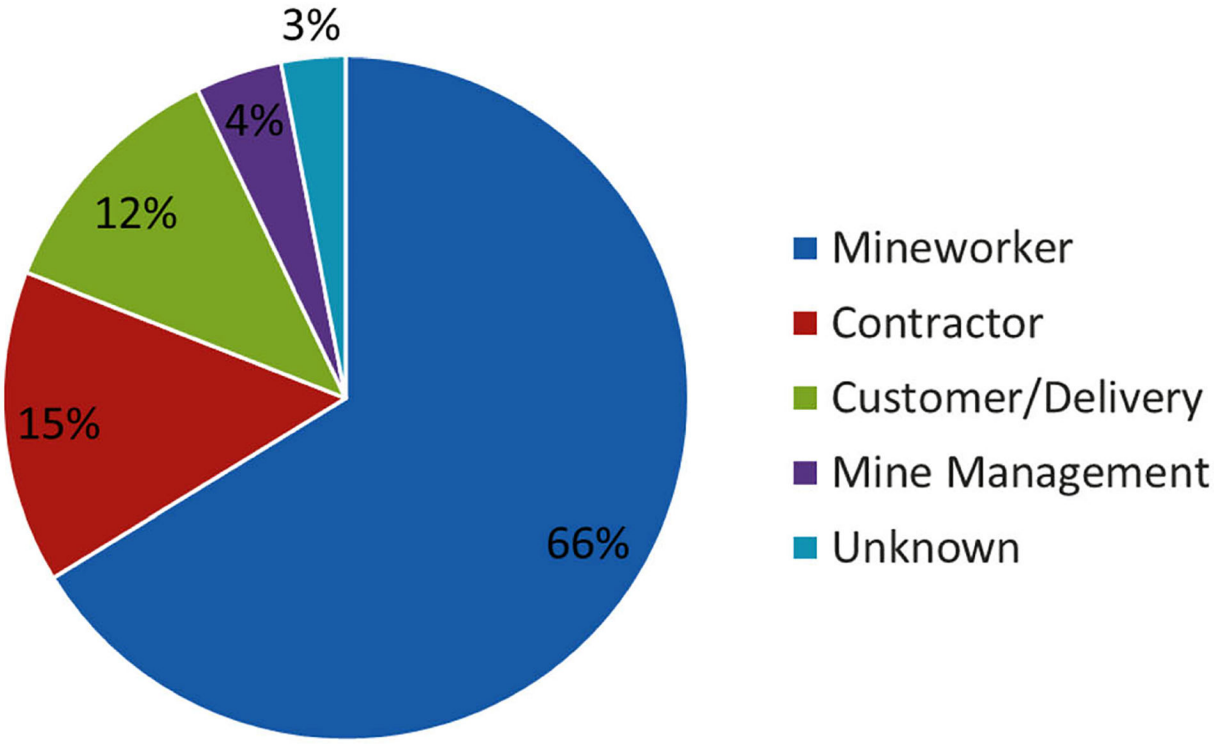

Fig. 2.
Worker employment type for fall-related metal/nonmetal imminent danger orders issued by MSHA between 2010 and 2017

Table 1

Classifications for all metal/nonmetal imminent danger orders issued by MSHA between 2010 and 2017 based on the MSHA “Classification of Mine Accidents” definitions

Classification	Count	Percentage
Slip or fall of person	1007	50.4%
Powered haulage	393	19.7%
Other	247	12.4%
Fall of face, rib, side, or highwall	91	4.6%
Hoisting	74	3.7%
Machinery	58	2.9%
Electrical	43	2.2%
Inundation	21	1.1%
Falling, rolling, or sliding rock or material of any kind	20	1.0%
Fall of roof or back	14	0.7%
Explosive and breaking agents	11	0.6%
Ignition or explosion of gas or dust	11	0.6%
Exploding vessels under pressure	5	0.3%
Handling material	2	0.1%
Fire	1	0.1%
Hand tools	1	0.1%
Total	1999	100%

Table 2

NIOSH coding scheme and definitions to determine the primary reason for the imminent danger order

Primary factor **- Secondary factor**	**Definition**
Fall protection	Fall protection or lack of was the primary reason for the imminent danger order
- Not provided	No fall protection provided to the employee
- No tie-off location	No suitable location was provide for the employee to tie off
- Unsafe for use	Fall protection itself was not safe for use and should not have been in service
- Not tied off	Employee was wearing fall protection but was not tied off
- Improper use	Fall protection was worn but not being used correctly, such as using the wrong length lanyard for the fall distance
- Lack of	Employee was not using any fall protection (a generic category if it did not fit the aforementioned four categories)
Safe access	Where safe access was the primary reason for the imminent danger order and was broken into two subcategories
- Not provided	No safe access such as stairs or ladders were provided to access the work location
- Not used	Safe access was provided but the employee did not use the provided safe access
Unsafe condition	Where the conditions present would have led to a fall
Unsafe act	There was an intentional, unsafe action that contributed to the employee's fall risk
Inadequate barricades, guarding, or signage	There was no or inadequate signage, barricades, or guarding to prevent inadvertent contact with fall hazards

Table 3

Primary and secondary factors for fall-related metal/nonmetal imminent danger orders issued by MSHA between 2010 and 2017

Count of cases Primary factor - Secondary factor	Procedural	Complex	Specialized	Total	Percent of grand total
Fall protection	759	124	3	886	83.8%
- Lack of	666	110	2	778	73.6%
- Not tied off	39	5		44	4.2%
- Not provided	24	4		28	2.6%
- Improper use	17	2		19	1.8%
- No tie-off location	10	3		13	1.2%
- Unsafe for use	3		1	4	0.4%
Safe access	51	38		89	8.4%
- Not provided	43	38		81	7.7%
- Not used	8			8	0.8%
Unsafe act	50	15	1	66	6.2%
Inadequate barricades, guarding, or signage	9	1	1	11	1.0%
Unsafe condition	5			5	0.5%
Grand total *	874	178	5	1057	100.0%
Percent of grand total	82.7%	16.8%	0.5%	100.0%	

* Total *n* is equal to 1007 cases. The grand total of 1057 shown in this table accounts for cases that were coded into two or more categories

Forty-six cases were coded with primary factors of both “fall protection” and “safe access”

Three cases were coded with primary factors of both “fall protection” and “inadequate barricades, guarding, or signage”

One case was coded with secondary factors of both “not provided” and “no tie-off location”

Table 4

Reference activity, primary factor, and height for the work surface of “truck”

Count of cases					
Reference activity	**Height above ground**				**Total**
- Primary factor	≤ 5 ft	> 5–10 ft	> 10–15 ft	> 15 ft	
Tarping; opening/closing hatch		34	23	1	58
- Fall protection		29	21	1	51
- Safe access		4			4
- Unsafe act		1	2		3
Hand load; hand shoveling/mucking	1	20	6	2	29
- Fall protection	1	20	5	1	27
- Unsafe act			1	1	2
Leveling load	1	17	2		20
- Fall protection	1	16	2		19
- Unsafe act		1			1
Cleanup	2	11	4		17
- Fall protection	2	8	4		14
- Unsafe act		2			2
- Safe access		1			1
Machine maintenance/repair	2	9	1		12
- Fall protection	2	8	1		11
- Safe access		1			1
Grand total	6	91	36	3	136

Table 5

Reference activity, primary factor, and height for the work surface of “conveyor”

Count of cases					
Reference activity	**Height above ground**				**Total**
- Primary factor	≤ 5 ft	> 5–10 ft	> 10–15 ft	> 15 ft	
Machine maintenance/repair	5	28	13	10	56
- Fall protection	3	24	13	9	49
- Safe access	2	4		1	7
Walking/running		5	4	1	10
- Fall protection		3	4	1	8
- Unsafe act		1			1
- Safe access		1			1
Chute, pull, or free	1	6	1	2	10
- Fall protection	1	4	1	1	7
- Safe access		1		1	2
- Unsafe act		1			1
Hand load; hand shoveling/mucking		7		2	9
- Fall protection		5		2	7
- Unsafe act		1			1
- Safe access		1			1
Cleanup	1	5			6
- Fall protection	1	4			5
- Safe access		1			1
Grand total	7	51	18	15	91

Table 6

Reference activity, primary factor, and height for the work surface of “screen”

Count of cases					
Reference activity	**Height above ground**				**Total**
- Primary factor	≤ 5 ft	> 5–10 ft	> 10–15 ft	> 15 ft	
Machine maintenance/repair	4	13	19	5	41
- Fall protection	4	11	17	5	37
- Safe access		1	2		3
- Unsafe act		1			1
Welding and cutting		3	2	1	6
- Fall protection		3	2	1	6
Walking/running		3			3
- Fall protection		1			1
- Unsafe act		1			1
- Inadequate barricade/guard/sign		1			1
Inspect equipment			2		2
- Fall protection			2		2
Cleanup		1		1	2
- Fall protection		1		1	2
Surface construction NEC			1	1	2
- Fall protection			1	1	2
Grand total	4	20	24	8	56

Table 7

Reference activity, primary factor, and height for the work surface of “crusher”

Count of cases					
Reference activity	**Height above ground**				**Total**
- Primary factor	≤ 5 ft	> 5–10 ft	> 10–15 ft	> 15 ft	
Machine maintenance/repair	3	10	9	1	23
- Fall protection	2	8	9	1	20
- Safe access	1	1			2
- Unsafe act		1			1
Other NEC	2		1		3
- Fall protection	1		1		2
- Safe access	1				1
Welding and cutting		2	1		3
- Fall protection		1	1		2
- Safe access		1			1
Cleanup		1	2		3
- Fall protection		1	2		3
Chute, pull, or free			3		3
- Fall protection			2		2
- Safe access			1		1
Grand total	5	13	16	1	35

Table 8

Reference activity, primary factor, and height for the work surface of “highwall”

Count of cases					
Reference activity	**Height above ground**				**Total**
- Primary factor	≤ 5 ft	> 5–10 ft	> 10–15 ft	> 15 ft	
Drilling		6	5	15	26
- Fall protection		6	5	15	26
Blasting		1	1	4	6
- Fall protection		1	1	4	6
Handling supplies or material			1	1	2
- Fall protection			1	1	2
Other NEC			1	1	2
- Fall protection			1	1	2
Idle (eating lunch, coffee break)			1	1	2
- Fall protection			1	1	2
Grand total	0	7	9	22	38