Mining industry fatality statistics: the problem of tailings facility fatalities

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August 2023

Introduction

Since 2012, global mining companies have been publishing data on their occupational safety performance via their peak body, the International Council of Mining and Metals (ICMM). The aim of this initiative is to drive safety improvements across the industry. In its most recent report, for the year 2022, the ICMM concludes

> We can draw strength from the many years of comparable data contained in this report, where through collective developments we see a downward trend in fatality and serious injury frequency[1].

However, when we focus on rare but catastrophic events, in particular tailings facility failures, the picture is not so clear. The aim of this paper is to highlight the problem that such events pose for the interpretation and policy implications of fatality statistics, and to suggest a way forward.

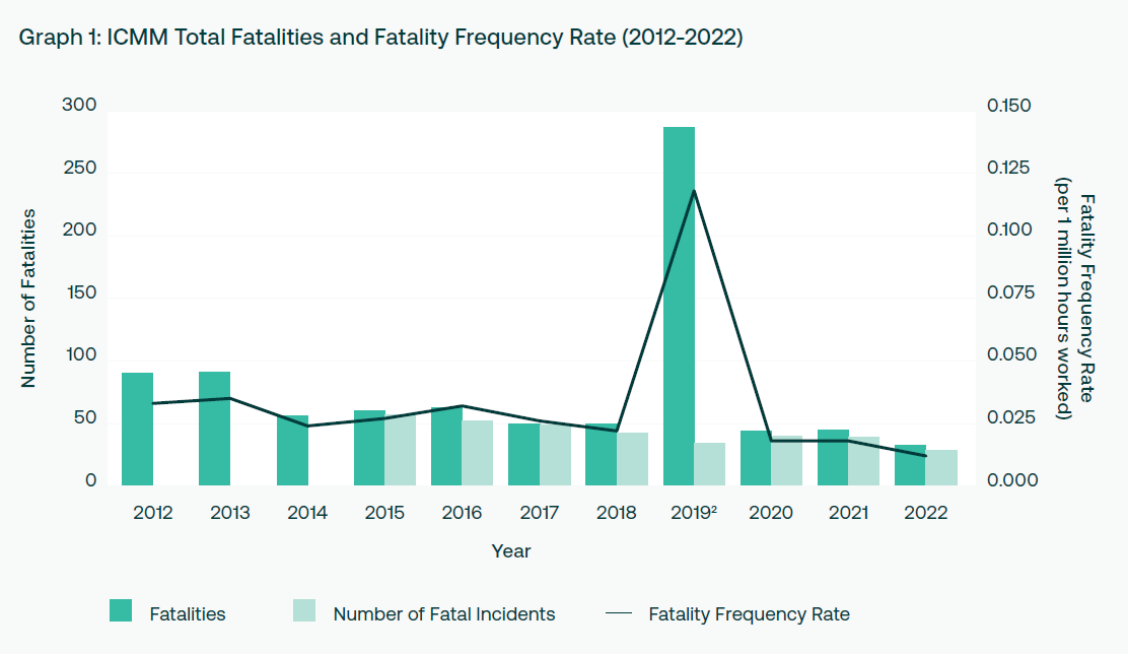
By way of preliminary, it should be born in mind that the data discussed here are drawn from the 26 global mining companies that are members of the ICMM. There are many other smaller mining companies that do not belong to the ICMM and thousands of tiny so-called artisanal mines, many of which are illegal. It is estimated that 90% of the world's miners work in these tiny mines[2] The number of deaths occurring in these artisanal and small mine environments is unknown, but it is likely to dwarf the numbers reported by ICMM members.

A second preliminary point is that the ways that companies report their data are not unform and critics point out that some deaths remain unreported as a result. The ICMM has done its best to standardise the way its member companies report their data and its reports carefully footnote where companies depart from these conventions. These matters are not the focus of interest here.

The problem

To set up the problem, consider graph 1, taken straight from the ICMM's report for 2022. This is the graph on which the report bases its conclusion that there has been a downwards trend in fatalities and fatality rate - fatalities per million hours worked[3].

[1] ICMM "Safety Performance Report: Benchmarking Progress of ICMM Company Members in 2022", p1
[2] (WSJ, 31/12/2019, https://www.wsj.com/articles/the-hidden-deaths-of-mining-11577825555.
[3] "Hours worked" is the gender-neutral replacement for the older term "manhours"



As is obvious, the year 2019 is a glaring exception to this trend. This was the year of the Brumadinho tailings facility disaster in Brazil, that killed 270 people, 250 of them workers The claim that there has been a decreasing trend relies on treating this year as an exception and excluding it from further analysis.

So it is that the report for 2022 contains statements of the following type:

> "For four years, since 2017, underground has been the main location of fatalities (excluding the Brumadinho tailings facility collapse in 2019…"

But there is something unsatisfactory, about a safety report that excludes a large number of deaths on the basis that they were caused by an exceptional event. This is all the more so if we recognise that almost any linear trend analysis that *included* the Brumadinho accident would show an upwards trend over this period, not the downward trend identified by the ICMM. For instance, the simplest way to identify a linear trend is to collapse the data into two categories, the first five years and the last five years (omitting the middle data point for simplicity). The number of fatalities in the first 5-year period is 360, while the number of fatalities in the last five-year period is 459 - an increasing trend! Intuitively, this is an equally unsatisfactory result.

One way to deal with this dilemma is to recognise that exceptional events require a separate discussion and must give rise to policy responses that are additional to policy responses arising from any analysis that excludes them.

The 2022 report fails to do this and, as a result, while it discusses ways of reducing fatalities from hazards, such falls of ground and mobile equipment, it has nothing to say about how to reduce the fatality risk posed by tailings facility failure. This is problematic because efforts to make tailings facilities safer must be ongoing, regardless of whether there have been tailings facility fatalities in the year under discussion. A safety report that says nothing about such fatalities, simply because they have not occurred in the year in question is missing a vital part of the safety picture. It is inadvertently contributing to the complacency with respect to such failures that develops when several years pass without a catastrophic incident.

This last claim may need further explanation. Rare but catastrophic accidents in hazardous industries are often followed by periods of intense effort on the part of regulators, the companies directly involved, and other companies in the industry, to ensure that such an accident never happens again. Yet, as the years go by without a repeat, memories fade, and policies and procedures adopted after the accident start to be seen as unnecessarily onerous and expensive and are progressively abandoned, until history repeats itself. There is some evidence in the oil and gas industry that this return time is roughly 10 years[4]. A study of fatalities in Queensland mines, identified a similar phenomenon – a fatality cycle with a period of roughly 2 years - a year in which a spate of fatalities occurs followed by a year in which there are no deaths, followed in turn by another year of fatalities[5]. There is no doubt that there has been an intense effort to reduce the risk of tailings facility failures following the unprecedented Brumadinho disaster, but only time will tell how successful this has been.

At this point it is worth documenting the decline in emphasis on tailings facility failures in the annual safety reports as the Brumadinho accident receded into the past.

The report for 2019, the year of the accident, includes considerable discussion of the incident. In addition, under the heading "Connection to ICMM's strategy and action plan" we find this:

> [the data in the report] informs ICMM's focus areas. Specifically, our action on tailings and the Innovation for Cleaner, Safer Vehicles (ICSV) programme …

In this year, then, the report does indeed treat tailings facility management as a special focus area.

Moving to the report for 2020, we find this:

> The data compiled in this report informs leadership discussions about the step change required to reach our goal of zero fatalities and supports an evidence-based approach to ICMM's programmatic focus on health and safety. Recently this has included our action on tailings, critical control management and the Innovation for Cleaner, Safer Vehicles (ICSV) initiative which aims to accelerate the innovations required to improve equipment safety and reduce emissions.

There is also mention of the new Global Industry Standard on Tailings Management, developed in the wake of the Brumadinho disaster[6] .

In short, in the report for 2020, tailings facility failure still gets a special mention, even though there were no tailings related fatalities that year.

However, the report for 2021 specifically excludes Brumadinho from the analysis and makes no mention of policies concerned with the management of tailings facility risk.

The report for 2022 repeats this pattern, as we have already seen. So it is that safety with respect to tailings facilities has effectively disappeared from the ICMM safety reports. Unless something is done, the ICMM safety reports will have missed a golden opportunity to

[4] The Marsh report, "The 100 Largest Losses in the Hydrocarbon Industry", 26th edition, 2020**, p22**

[5] Sean Brady, *Review of all fatal accidents in Queensland mines and quarries from 2000 to 2019*, p20

[6] See Hopkins A & Kemp D *Credibility Crisis: Brumadinho and the Politics of Mining Industry Reform* (CCH, Sydney, 2021)

contribute to the step change that so many hope the Global Standard on Tailings Management will achieve. I shall come back to this later in the paper.

Additional limitations of ICMM data in relation to tailings facility deaths

Brumadinho was certainly the worst tailings facility failure, in terms of fatalities, during the 11 year period covered in graph 1. But it was not the only one. Four years earlier, in 2015 the failure of a tailings facility at Samarco, also in Brazil, killed 19 people, including 14 workers[7], and polluted the river for nearly 1000 kms to the sea, destroying or damaging the livelihood of many thousands of people. This was an environmental disaster, as well as a disaster in terms of lives lost. But a glance at graph 1 reveals that it had no discernible impact on the ICMM statistics for that year. In fact the Samarco fatalities were not counted in the ICMM data because the Samarco company was not itself a member of the ICMM.

But that is not quite the whole story. Samarco was jointly and equally owned by BHP and Vale. Both these companies are currently members of the ICMM, although at the time of the accident, Vale was not. However under the ICMM counting rules these fatalities were not attributable to BHP, neither in whole nor in part. Hence there is no trace of this human disaster in the ICMM data. This is truly an anomaly. Real progress towards zero fatalities will depend on holding the ultimate owners accountable. At the very least, graphs like the one above should draw attention to major anomalies of this nature in footnotes.

The ICMM data suffer another significant limitation when it comes to dealing with tailings facility failures. The Brumadinho incident killed 270 people of whom 250 were workers. The remaining 20 were downstream residents. Likewise, the Samarco disaster killed 19 people of whom 4 were inhabitants of a village downstream. Yet only workers employed at the facility sites are counted in the ICMM statistics.

For various reasons, all deaths should be counted. First, these downstream fatalities are a result of major workplace accidents. In many jurisdictions the companies concerned are held to be just as accountable for the deaths of members of the public as they are for people employed at the site. Furthermore, the public does not distinguish between these two categories of victims and public reaction will be a function of the total numbers killed, not just the number of workers. What is at stake here is the social licence to operate and mining companies would be well advised to acknowledge this broader view. Arguably, therefore, the presentation of the data should include all people killed as a result of workplace incidents, not just people working at the site. At the very least graphs should footnote any deaths that have occurred to members of the public.

The strategy of monitoring precursor events.

For the remainder of this paper I want to focus on the fundamental problem presented above. That is, that where annual fatality statistics are used to prioritise safety interventions, as in the case of the ICMM data, the absence for several years of any fatalities arising from a particular hazard will result in a loss of focus on that hazard. The result is that a major hazard may be

[7] ICMM Safety Performance Report for 2015

poorly managed for a period of years, without this being noticed, until it again breaks through the surface of normality, causing a large number of deaths. As explained above, this is a common problem in major hazard industries.

We can formulate this problem in a slightly different way. If a hazard is creating significant number of fatalities each year across an industry, then it makes sense to focus on that annual number and try to drive it downwards. Examining trends retrospectively will give an indication of how successful safety interventions have been in relation to these hazards. For example, given that roof falls in underground mines are causing a significant number of fatalities annually, then trends in roof fall fatality figures will be an indicator of how well the hazard of roof fall is being managed. But when, for most years, the number of fatalities arising from a particular hazard is zero, as is the case with tailings facility failures, focussing on numbers of deaths can tell us nothing about how well the hazard is being managed. This requires a different approach.

While major accidents are relatively rare, the *precursors* to major accidents are more common. In the petrochemical industries, hazardous materials such as flammable gases need to be safely contained in pipes or tanks. A loss of containment, by means of leak, rupture, or overflow, is an occasion of heightened risk. Not every loss of containment leads to a major accident event, but most major accident events in these industries are preceded by a such a loss of containment. Such a loss can therefore be thought of as a precursor event. Where the number of these events is significantly more than zero, it can be used to monitor changes in risk level over time and companies can set about driving the number downwards. The petro-chemical industries now now treat of losses of containment as precursor events to be reduced to few as possible[8].

Precursor events are warning signs. They are warnings that risks are not under control to the necessary degree. They do not necessarily indicate *what* needs to be done – only that *something* needs to be done. *What* needs to be done is a matter for management to decide.

The pre-eminent example of the precursor event strategy can be found in air traffic control organisations (ATCs)[9]. The most dreaded unwanted event for an ATC is a mid-air collision. Accordingly, ATCs specify the separation between aircraft that must be maintained. The failure to maintain the specified separation is called a *breakdown of separation*. It is a precursor to a collision. A breakdown of separation does not mean that aircraft are dangerously close; simply that they are closer than they should be, that one or more controls has failed, and that, although the risk of collision may still be extremely low, it has increased. ATCs therefore treats the number of breakdowns of separation as an indicator to be closely monitored. Any increase in the number is regarded as a matter of great concern.

To apply this precursor approach, hazardous industries must identify the precursors to each type of major accident to which they are vulnerable and collect and publish the statistics on such events.

This paper is concerned with fatalities arising from tailings facility failures. A logical precursor to such a fatality is the occurrence of the tailings facility failure itself. Such failures may kill

[8] API (American Petroleum Institute) Recommended Practice 754. Unfortunately, only the largest containment losses are publicised and major companies have very low numbers of these large losses - perhaps only one or two per year - with the result that variations from year to year are statistically insignificant.
[9] Hopkins A, *Learning from High Reliability Organisations*, Sydney, CCH, 2009

no one, but uncontrolled and unexpected flow of tailings mud are obviously times of elevated fatality risk for people downstream. Reducing the frequency of such failures will thus reduce the risk of tailings-related fatalities. The question therefore is whether tailings facility failures occur often enough to be able to chart trends over time.

One estimate is that "major failures" occur at a frequency of less than 2 to 5 per year but "minor failures" at a frequency of 35 per year[10] These figures are certainly very imprecise and are subject to reporting biases, (presumably under-reporting biases), but a frequency of 35 cases per year is large enough to allow for trends over time to be identified.

The above figures are for the industry as a whole. ICMM data would be a subset of this industry-wide data, but the numbers may still be large enough for present purposes. If so, then whenever the ICMM presents more general fatality trend data, it should consider presenting data on trends in the number of tailings facility failures, as a surrogate for tailings facility fatality risk.

As noted above, trend data can be used to monitor the effect of safety initiatives over time. Once the Global Standard is fully implemented, we would expect a discernible reduction in the number of tailings facility failures. This would in turn imply a downward trend in the risk of fatalities caused by tailings facility failure.

Facility level data on tailings failure risk

When the focus is on individual facilities rather than the industry as a whole, there are more precise ways of monitoring fatality risk trends which are of greater value to facilities in minimising their own risks.

Many jurisdictions require that major accident risks in mining be managed by putting in place controls, in particular, a small number of critical controls. ICMM guidance defines critical controls as follows:

> Critical controls are controls that are crucial to preventing, or mitigating the consequences of, an MUE [Material Unwanted Event]. The absence or failure of a critical control will significantly increase the risk of an MUE occurring, despite the existence of the other controls[11].

These controls must be closely monitored to ensure they are working as intended. Where a critical control is not working effectively, or more precisely fails to meet a performance criterion, then, by definition, the risk is significantly increased. Critical control failures are therefore precursors to major accidents. In turn, data on critical control failures can be used to monitor trends on how well these risks are being managed at the facility level.

A second and related approach to identifying precursors at the facility level is the TARP (Trigger Action Response Plan). This strategy appears to be unique to the mining industry. In

[10] See "Trends in the stewardship of tailings facilities" T.E. Martin and M.P. Davies AGRA Earth & Environmental Limited, Burnaby, B.C. Canada. See also https://www.wise-uranium.org/mdaf.html

[11] ICMM Critical Control Management Implementation Guide, p30

what follows I shall talk about TARPS in the context of tailings facility failures, but the ideas apply to the management of all major accident hazards in mining.

The Global Industry Standard on Tailings Management defines a TARP as follows:

> A TARP is a tool to manage risk controls, including critical controls. TARPs provide pre-defined trigger levels for performance criteria that are based on the risk controls and critical controls of the tailings facility. The trigger levels are developed based on the performance objectives and risk management plan for the tailings facility. TARPs describe actions to be taken if trigger levels are exceeded (performance is outside the normal range), to prevent a loss of control. A range of actions is pre-defined, based on the magnitude of the exceedance of the trigger level[12].

The use of Trigger Action Response Plans is described in more detail in requirement 7.4 of the Global Standard.

There may be three or four trigger levels, the most extreme being to evacuate people from danger. Lower levels require less extreme responses. In a four-level system, if the number of level-four trigger events is significantly more than zero, this can be used to monitor trends; if not, some lower level trigger events may be occurring sufficiently frequently to be useful for the purposes of identifying trends over time.

It is possible that some of these critical controls and TARPS are common or could be made common to all tailings facilities. Dam over-toppings and measured dam wall movements have been suggested. If so, it may be possible to aggregate the data to provide indicators of tailings facility risk trends for ICMM member companies as a whole. This would be a major advance!

Conclusion

ICMM annual fatality statistics tend to treat deaths arising from tailings facility failure as exceptional events, to be excluded from further analysis. This paper suggests ways they can be incorporated into discussions of fatality trends so as to maintain attention on this hazard, even though years may pass without such a fatality. I hope that the ICMM will be able to implement some of these ideas in future reports.

[12] p33