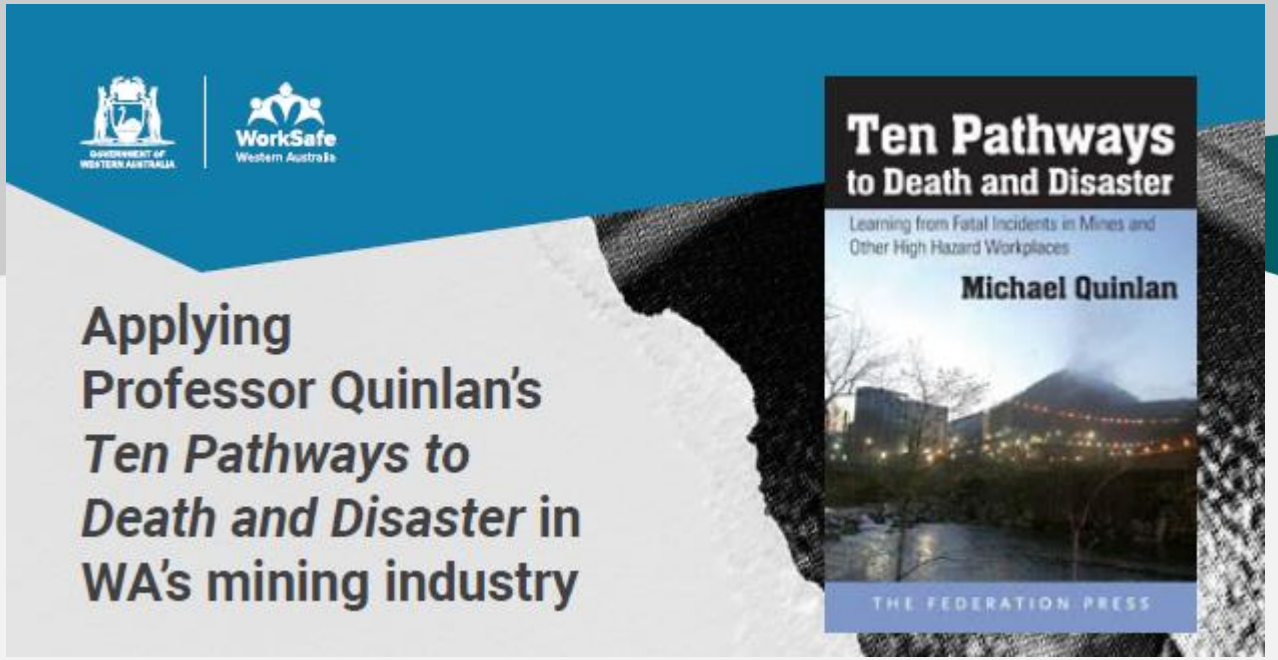
Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

WorkSafe
Western Australia



Welcome

Please be seated ready to start at 8.30 am

Switch mobile phones to silent

Before we start

- Emergency procedure – location of exits, follow instructions

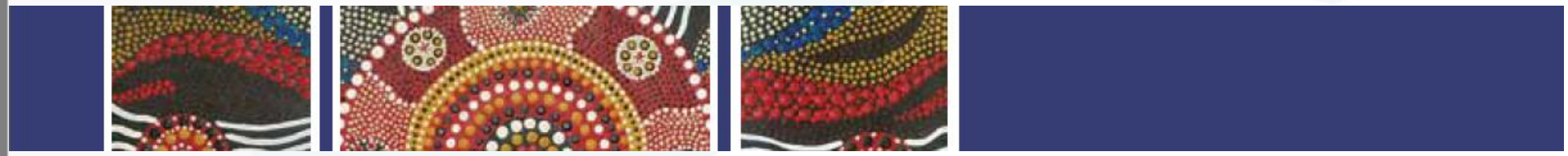
- Photos – please let us know if you don’t want yours taken or published

- Copies of presentations – available online as toolbox presentations in next month or so

- Slido – please log in using the app on your mobile device

- Location of toilets

Acknowledgement of country



The Department of Mines, Industry Regulation and Safety would like to show its respect and acknowledge the Traditional Custodians of the Land, of Elders past and present, on which this meeting takes place

Today’s presenters

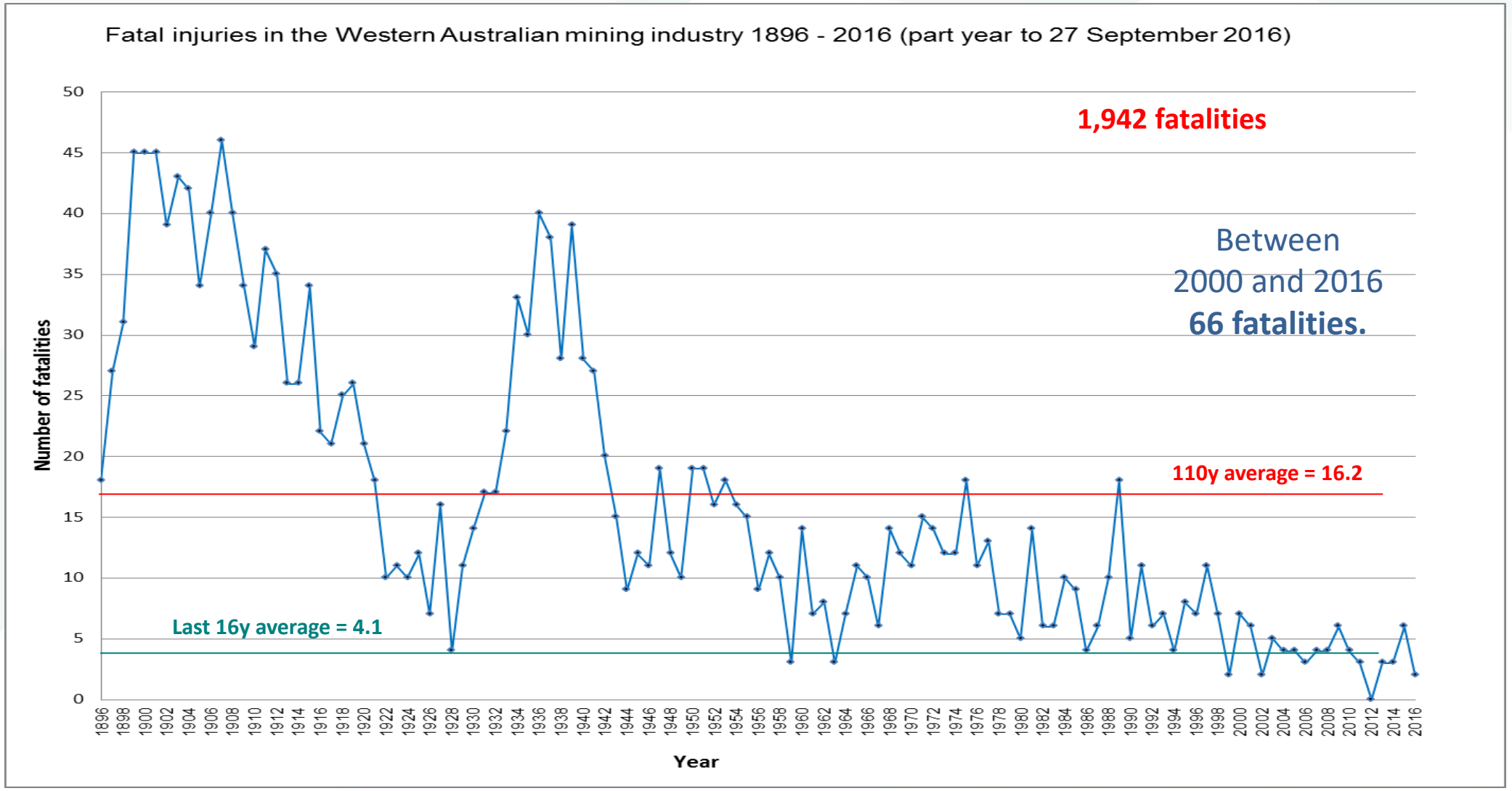
- **Emeritus Professor Michael Quinlan**
- Dr Martin Ralph - Regional Inspector of Mines
- Peter Nissen - Inspector of Mines – (Work Health and Safety)

We would also like to acknowledge the presence of our colleagues from the Mines Safety Directorate.

Today's Programme

Time	Topic	
8.00 am	Registration	
8.30 am	Welcome and opening remarks	
8.40 am	Setting the scene: A recap of the 2017-19 Roadshow data	Martin Ralph
9.00 am	Background to the Ten Pathways to Disaster	Prof. Quinlan
9.30 am	Q and A	
9.50 am	The 10 Pathways – What they are, and their significance	Prof. Quinlan
10.30 am	Morning tea	
10.50 am	The 4 Key Pathways from 2017-19	Martin Ralph and Peter Nissen
11.10 am	How to address weaknesses in the 4 Key Pathways	Prof. Quinlan
11.30 am	Q and A	
11.50	The Ten Pathways – recent data	Prof. Quinlan
12.20 pm	What has changed – from 2019? (group survey)	Workshop
13.00 pm	Summary and closing remarks	Prof. Quinlan and Martin Ralph

WA mining – historical fatalities to 2016

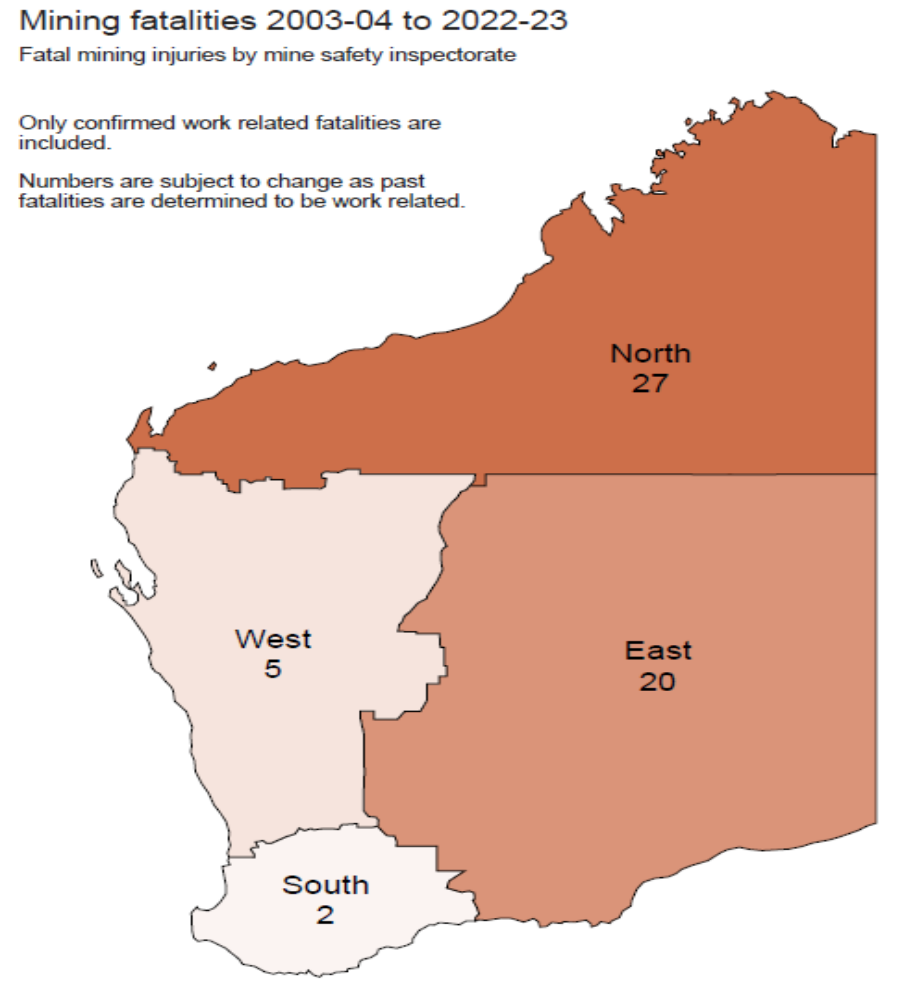


Setting the Scene

- In 2020 WA's mining industry employed ~ 140,000 workers
  - Approximately 10% of the State's workforce.
- 77 mining fatalities reported between 2000 and 2020
  - 15% of all workplace fatalities
- Conclusion:
  - the mining industry is over-represented in workplace fatality statistics.

Jenke et al (2022)

Where did the fatalities occur?



Region	Fatalities per million hours
North	0.017
East	0.024
West	0.015
South	0.004

WA mining industry fatalities 2000-2018

Hazard Category	Fatalities	Hazard Category	Fatalities
Fall from height	12	Inrush	3
Maintenance Procedure deficiency	8	Open pit-wall failure/subsidence	2
Underground rockfall	5	Heat exhaustion	3
Vehicle collision	5	Suspended load	2
Vehicle over edge	4	Falling equipment	2
Vehicle runaway	5	High pressure equipment	1
Vehicle rollover	3	Engineering design	1
Tyres	3	Explosions and fires	1
Crush by Machinery	5	Explosives	1
Electrical contact	3	Natural event	2
Total - 20 Hazard Categories		**71**	

2017-2019 Roadshow Data

- Anonymous questionnaire designed to collect perceptions of their employer's effectiveness in each of the Quinlan Ten Pathways was provided to attendees of the DMIRS Mines Safety Roadshow
- 10-point Likert scale, from 1 to 10, with 10 being the most effective.
- 11 towns/cities and 2 mine sites totalling 2009 participants:
  - 2017 = 768,
  - 2018 = 695, and
  - 2019 = 546.

2017-2019 Roadshow Data

- Mean scores for the Ten Pathways:
  - 2017: 6.55
    - In 2017 Pathway 5 scored the lowest mean score of 5.82.
  - 2018: 6.96
  - 2019: 6.71

- Lowest Mean score in 2017 and 2018 – Pathway 5 – Failures in Auditing
- Lowest Mean score in 2019 – Pathway 1 – Failures in Design, engineering, technical and maintenance.

2017-2019 Roadshow Data

- **North region** had the highest means for:
  - Pathway 3: Failures in risk assessment,
  - Pathway 6: Economic pressures compromising safety, and
  - Pathway 10: Emergency and rescue resources and procedures
- **Mid-west region** had the lowest means for:
  - Pathway 1: Design, engineering, technical and maintenance failure, and
  - Pathway 4: Failures in management systems and hazard management.

Superintendents/Managers appear to have a higher perceptions of organisational performance when compared to HSRs.

Learning from Failure: Repeat/pattern failures leading to mine fatalities

Mine Safety Forum

Western Australia August 2023

Emeritus Professor Michael Quinlan UNSW PhD FASSA
(Launceston Tasmania) m.quinlan@unsw.edu.au

Traumatic workplace death in context

- 2020: 4746 fatal work injuries in USA (3.4 per 100,000 FTE);
- 2021: 194 work fatalities in Australia (1.5 per 100,000 FTE)
- From early 20th century incidence of work fatalities declined (especially multiple death incidents)
- But relatively stagnant (maybe small decline) over past decade

Traumatic workplace death in context

- Four sectors account for over 70% of workplace fatalities – construction, road transport, farming/fishing/forestry and mining (less so in Australia)
- Doesn’t include work-related suicide which also concentrated in particular occupations (construction, road transport, emergency, police & some healthcare).
  - Note: WHO endorse peer to peer suicide prevention programs like Mates In Construction (WHO, 2021) as exemplar intervention
    - Mates In Mining uses this approach.
- Largely exclude death from work-related diseases:
  - estimated to kill 4-6 times traumatic fatalities

Ten Pathways: Multi-national research findings

- Idea came from considering mine safety since 1986
  - looking at past disasters,
  - talking to managers, engineers & safety rep
  - MQ involvement in:
    - NSW mine safety review (2004);
    - Beaconsfield investigation (2006); and
    - Pike River RC & ERG (2010-13);
  - Combined with prior research

The cost of failure

- **Fatalities can have major impact on operations and workforce morale.**
  - Production pressures and ambitious targets need to be balanced against this as Pike River, Beaconsfield, Grosvenor demonstrate
- **There is also an immense human cost**.
  - Every workplace death impacts heavily on 16-20 people including family members.
  - These impacts investigated by pioneering federally funded Australian study (2007-20) based on interviews with institutional representatives/families & global survey*
- **Survey findings:**
  - 61% experiencing (PTSD),
  - 44% (MDD) and
  - 42% (PGD)

(Matthews et al 2019)

The cost of failure

- **Significant economic impact (esp. self-employed, older, those working long hours)**
  - number struggling financially grew from 24% to 62% after death;
  - 74% made workers compensation claim but delays, entitlement level & dissatisfaction;
  - Other significant financial help was family, friends, self-help groups and services

(Matthews et al 2022)

- **Also evidence of significant carryover financial effects on children (ie intergenerational – requires more investigation)**
- **What families want regarding prevention:**
  - Clear and timely information of how/why death occurred
  - Deceased not dehumanised by legal processes
  - Identification of responsibility and timely prosecution if breach with significant penalties that will act as deterrent
  - Remedial measures so other families spared similar tragedy

Why look for failure patterns?

- **Failure can be as instructive as success, especially in case of low frequency/high impact events where**
  - Statistical records like workers' compensation, lost day and medical treatment injuries of little value
  - Need to use different indices, KPIs and remedies
- **Examining series of incidents identifies recurring causes, why systems fail & how to remedy**
  - Managing risk is about identifying patterns (causes and effects) and examining series of failures is arguably best way to identify patterns
- **Strategic decision making needs to draw on past while recognising risk of misinterpretation & change**

Ten Pathways: Multi-national research findings

- **Major mine hazards have been known for 200+ years**
- **Data since 1992 was collected from 5 countries:**
  - Australia,
  - Britain,
  - Canada,
  - New Zealand; and
  - USA
- **46 fatal or multiple fatality accidents**

Ten Pathways: Multi-national research findings

- **Detailed examination of 24 fatal incidents in coal & metalliferous mines in 5 countries**.
  - 15 involved 3 or more deaths;
  - 9 single fatality events.

- **Identified 10 repeat/pattern causes**.

Ten Pathways: Multi-national research findings

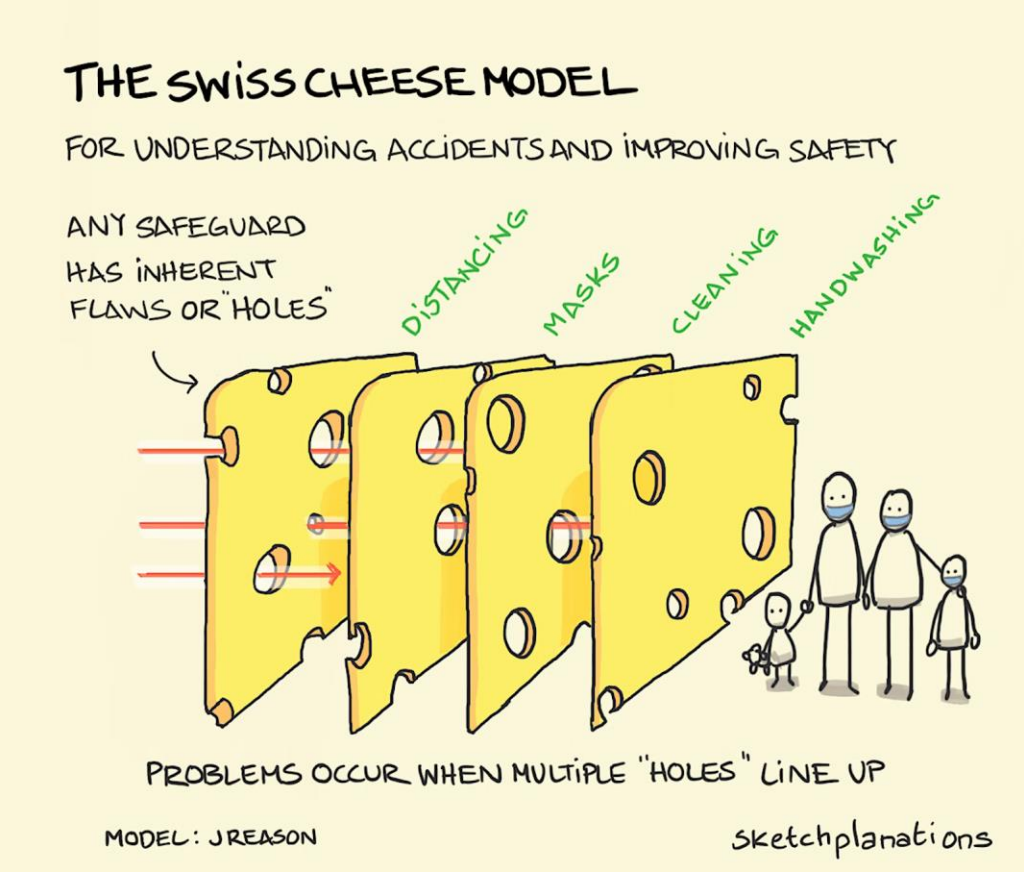
- **Examined over 30 multiple fatality incidents in 10 countries in other high hazard workplaces**
  - chemical plants
  - Refineries
  - Oil rigs
  - Aviation
  - Shipping; and
  - Road transport.

- **Same pattern causes.**

Ten Pathways: Multi-national research findings

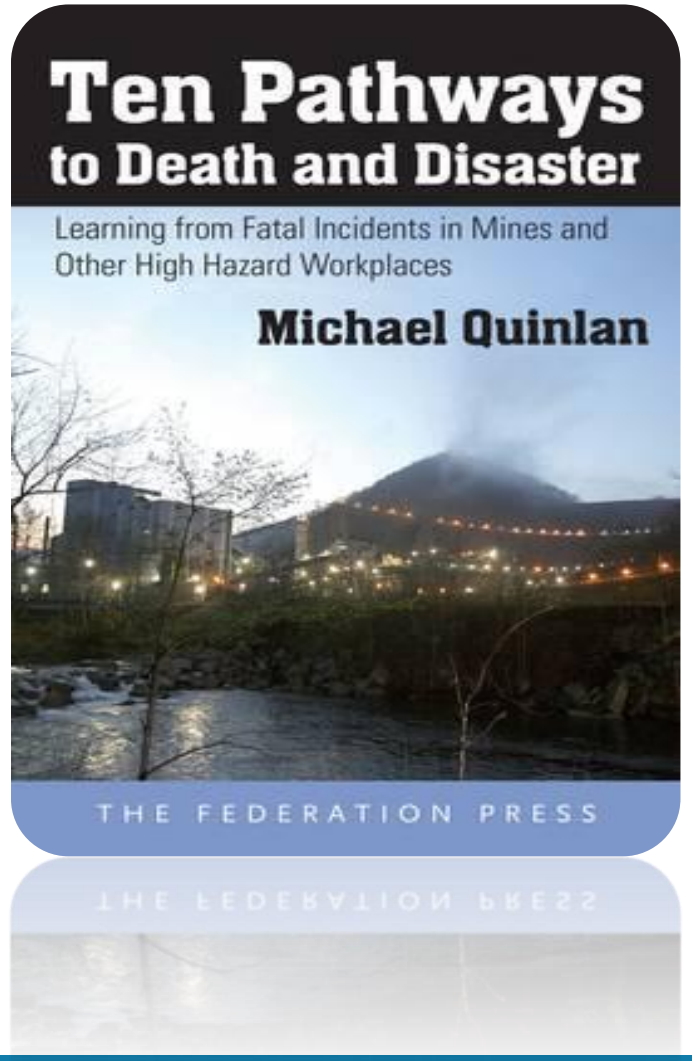
- **Identified 10 causal pathways to fatal incidents**
  - at least 3 present in virtually all mines;
  - majority had 5 or more
    - Pike River had 10:
    - BTW Grosvenor had 8.
- **Causal pathways applied to mass fatality events (aka disasters) and single fatalities (confirmed by subsequent research)**
- **More thorough the investigation the more pattern causes identified (main reliance on official reports)**

Latent failures and the Swiss Cheese model



- James Reason (1990, 2008) developed concept of latent failure ie a flaw in a health & safety regime that could precipitate serious incident but didn't have immediate effect
- Could remain undetected for long time until latent failures aligned to pierce multiple layers of defence (like slices of Swiss cheese)
- Question – Are there are specific latent failures that repeatedly lead to disaster and death? Ten pathways indicates there are.

Ten pattern causes



1. Design, engineering and maintenance flaws
2. Failure to heed clear warning signals (note similar findings re environmental disasters)
3. Flaws in risk assessment (hazard identification, likelihood/magnitude, controls/monitoring)
4. Flaws in management systems and changes to work organisation
5. Flaws in system auditing
6. Economic/production and rewards pressures compromising safety
7. Failures in regulatory oversight
8. Supervisor and worker expressed concerns prior to the incident
9. Poor management/worker communication/trust aka those controlling risk & those at risk
10. Flaws in emergency procedures, rescue and resources

Descriptions of the Ten Pathways (1)

Pathway	Description of Pathway
Pathway 1: Design, engineering, technical and maintenance flaws	The flaws in engineering, design and maintenance were mostly the result of poor decision making by management and were often known or should have been identified well before the fatal incident.
Pathway 2: Prior warnings or causes for alarm ignored	In many of the fatal incidents, it was observed that clear warnings and causes for alarm were ignored. In many cases, employees or supervisors had expressed their safety concerns prior to the fatal incident.
Pathway 3: Failures in risk assessment	A causal factor of many of the fatal incidents was a failure to undertake risk assessments or undertake them accurately. Effective risk assessments are based on informed knowledge of the hazard, evaluation of the effectiveness of risk treatments and control measures, and monitoring and review of the situation to detect change in risk.

Descriptions of the Ten Pathways (2)

Pathway	Description of Pathway
Pathway 4: Failures in management systems and hazard management plans	A focus on behavioural change, LTIs and poorly selected Key Performance Indicators can lead to complacency about major hazards. Catastrophic risk increases if well-documented procedures are not implemented and when there are major changes to work design.
Pathway 5: Failures in auditing	Auditing ensures that WHSMS are designed and implemented effectively and identifies areas for improvement. Auditing needs to be rigorous across all parts of the WHSMS. Overly routinized audits that don't act on information may overlook catastrophic hazards.
Pathway 6: Economic pressures compromising safety	Highlights the failure to control the influence of personal financial incentives and pressure on individuals to contribute to the production expectations. Financial pressures such as the use of incentive- or bonus-based regimes are commonly found to undermine safety.

Descriptions of the Ten Pathways (3)

Pathway	Description of Pathway
Pathway 7: Failures in regulatory oversight and inspection	The failure of the Regulator to provide feedback to an organisation on their compliance with legislation and safety performance was found to be a common catastrophic incident pathway.
Pathway 8: Worker and others expressing concern prior to the incident	Workers were seldom asked their views on safety at the mine, including evidence of concerns both prior to and pertaining to the incident. Failure to heed well-founded concerns was a common pathway of mine fatalities
Pathway 9: Poor management – worker communication and trust	Concerns the flow of critical information to and from the workers as well as the willingness to act on that information. Ineffective communication and trust may result in a variety of poor outcomes including mixed messages, inconsistent messages and lack of engagement with the work force which undermines their participation.

Descriptions of the Ten Pathways (4)

Pathway	Description of Pathway
Pathway 10: Emergency and rescue resources and procedures	Effective emergency management procedures play a critical role in mitigating the escalation of an incident. Failure to develop and implement effective emergency management systems endanger lives including safeguarding rescue personnel.

Significance of the Ten Pathways

Case Studies:

- Northparkes mine (1999)
- Mount Thorley mine (2011)
- CSA Copper Mine (2014)
- Ulan underground mine (2015)
- Mount Arthur mine (2017)

Northparkes mine (24 November, 1999)

Air-blast killed four

Pathway 1:
Height of void and location of bulkhead to protect against air blast inadequate (and management should have known this).

Pathway 3:
Failure to assess risk of void or bulkhead barrier and loss/absence of qualified experts to manage this.

Pathway 4:
Poor management of contractors

Pathway 5:
Inadequate monitoring of caving

PARKES Champion-Post

266 days until the Torch arrives in Parkes

Friday, November 26, 1999 — 107th Year of Publication — $1.10

FOUR KILLED IN MINING TRAGEDY

Massive blast of air proves fatal in freak accident

The Northparkes Mines at Goonumbla, where four men died in the underground section on Wednesday after a freak accident.

More pictures, reports on pages 2, 3 and 5.

Names of missing men released

Mick Magill's INGROUND POOLS ★ Concrete Pools ★ Fibreglass Pools Miami or Harvest

Don't Miss The 2nd Draw In PBI Annual $24,000 Christmas Giveaway

The most powerful diesel in its class... HOLDEN Rodeo

RODEO 4x4 TURBO DIESEL
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Northparkes mine (24 November, 1999)

Air-blast killed four

Pathway 6:

Production rate taking precedence over safety, caving problem & air blast risk well known

Pathway 7:

Inspectorate inadequate knowledge of block caving

Pathway 9:

Poor management/worker and worker/worker communication processes

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Mount Thorley mine (2011)

High potential incident: submerged dozer,

Pathway 1:

Didn’t examine water management issues including rain impact

Pathway 3:

Did broad-brush risk assessment of pit rating risk of plant entry into water as low (jarring of neck and back not dozer submerging/drowning) so only procedural controls.

Temporary barriers/signage efficacy not assessed.

Pathway 4:

Flaws in the communication/information between shifts and also management levels (as required by legislation)

Mount Thorley mine (2011)

High potential incident: submerged dozer,

Pathway 6:

Increased rate of overburden removal and expanded fleet to increase efficiency coincided with complaints of bullying and harassment

Pathway 7:

No specific regulatory guidance on hydrological hazards and risk in open cuts.

Unlike West Australia which required prior analysis of inflow, drainage and dewatering procedures after Mount Keith fatality

Pathway 8:

Prior shift supervisor raised sump issue

Mount Thorley mine (2011)

High potential incident: submerged dozer,

Pathway 10:

Had trouble exiting dozer (unable to open either door due to water pressure)

Had to wait until cabin almost flooded and water pressure equalised (didn’t panic due to training)

Confusion over sump location delayed arrival of emergency response team.

Source: Jackson (2021)

CSA Copper Mine Cobar (2014)

Worker was sucked into an underground sump drain and drowned.

The worker lost a scaling bar in the sump, and became concerned about it being sucked down to the level below and creating a risk.

He entered the sump to find it.

- OHSMS planning, risk control, and feedback failure

CSA Copper Mine Cobar (2014)

Worker was sucked into an underground sump drain and drowned.

Pathway 1:
The drain hole had been purposely blocked while drilling additional drain to the level below in another location. There was a lack of coordination between engineering and production personnel about water management and the impact of continued production on water accumulation.

Lack of engineering SSW – no SWP developed for blocking/unblocking the drain and fit-for-purpose equipment had not been identified and procured.

The work at heights procedure stipulated the use of an integrated tool carrier with work basket and harness was identified as the relevant procedure.

The ultimate control relied on a JSA (which was not undertaken) and compliance with a mine rule, ’do not enter a water filled sump’.

CSA Copper Mine Cobar (2014)

Worker was sucked into an underground sump drain and drowned.

Pathway 3: Lack of task specific RA
No broad-brush RA or change management for the mine dewatering project.

Pathway 4: OHSMS feedback failures
(a) Failure to record and transfer information between shifts and management and workers unblocking the drain did not know what was used to block the drain and therefore the best approach to unblocking it;

(b) Management failed to monitor the water buildup in the sump and inspect the sump before work was commenced;

(c) A communication breakdown during task allocation resulted in workers starting before the shift supervisor arrived;

(d) The mine had set compliance targets for hazard identifications and JSAs and although monitoring identified compliance was well below target no action was taken to determine the reasons for non-compliance.

CSA Copper Mine Cobar (2014)

Worker was sucked into an underground sump drain and drowned.

Pathways 2, 5, 6 & 7 also present.

Note:
The court found the worker failed to comply with procedures and rules and the company was not prosecuted for a breach. Source: Jackson (2023)

Ulan Underground Mine (2015)

Surface Incident - subcontractor seriously injured

Lack of safe systems of work, competence, and supervision

In 2015, a testing service subcontractor was seriously injured when the swaged pipe end fitting that was coupled to the compressed air supply via a flexible hose suddenly separated from the pipe end as the air supply pressure rose knocking the contractor off his feet

Ulan Underground Mine (2015)

Surface Incident - subcontractor seriously injured

Pathway 1: Inadequate engineering standards

(a) the pipe, which was used to deliver inert gas to the LW, was manufactured outside the design tolerance specification;

(b) failed to ensure competency and provide supervision to workers undertaking the task.

Pathways 4, 7, 8 & 9 also present

Ulan Underground Mine (2015)

Surface Incident - subcontractor seriously injured

Pathway 3: Flawed RA/informal RA failure

(a) the manufacturers RA was underspecified, and control measures were too general and failed to provide clear information on how the identified hazards were being controlled;

(b) the mine RA failed to identify risks associated with using compressed air instead of a safer non-compressible medium such as soapy water;

(c) the subcontractor's informal RA did not identify the risk of sudden separation of swaged fittings.

Ulan Underground Mine (2015)

Surface Incident - subcontractor seriously injured

Pathway 5: OHSMS feedback failures

(a) there was a documented SWP, but information given to subcontractors failed to include control measures identified following an investigation into a previous incident;

(b) a lack of consultation between the mechanical engineering manager and the technical services department contributed to the procurement and testing failures.

Actions after the incident:
The causal investigation recommended mines only use non-metallic pipe with factory swaged ends not field-swaged ends. Enforceable undertaking issued: Source: Jackson (2023)

Mount Arthur Open Cut mine (2017)

Contractor management failure

- Tyre replacement contract worker severely burnt while refuelling a tyre handler at the heavy vehicle refuelling station using free flow adapter nozzle.
- Refuelling equipment not compatible with tyre handlers.
- Subcontractors used adapter that bypassed the automatic cut-off.
- Forces acting upon the adapter caused it to eject from the filling neck and diesel fuel entered engine bay and ignited on the hot engine surface.

Mount Arthur Open Cut mine (2017)

Contractor management failure

- Pathway 1: Inadequate engineering standards
- there was no system to prevent access to the heavy vehicle refuelling station and subcontractors were not trained in its safe use.

- Pathway 3: Lack of task specific RA/risk not identified
- refuelling was not considered high-risk by the service contractor and no RA was carried out.

Mount Arthur Open Cut mine (2017)

Contractor management failure

- Pathways 4 & 5: OHSMS feedback failures
- Lack of clear downward communication to refuellers about their responsibility to refuel tyre handlers;

- Mine management was unaware that contractors were using the heavy-vehicle refuelling station and non-approved adaptor;

- Audits failed to identify the non-approved adaptor;
- management unaware of contractor issues and informal communication between service groups directing workers to the heavy-vehicle refuelling station.

- Contractor management – RA and supervision failed to provide subcontractor safe access to refuelling. Work demands and disorganization contributed to subcontractors using a non-approved adaptor.

Mount Arthur Open Cut mine (2017)

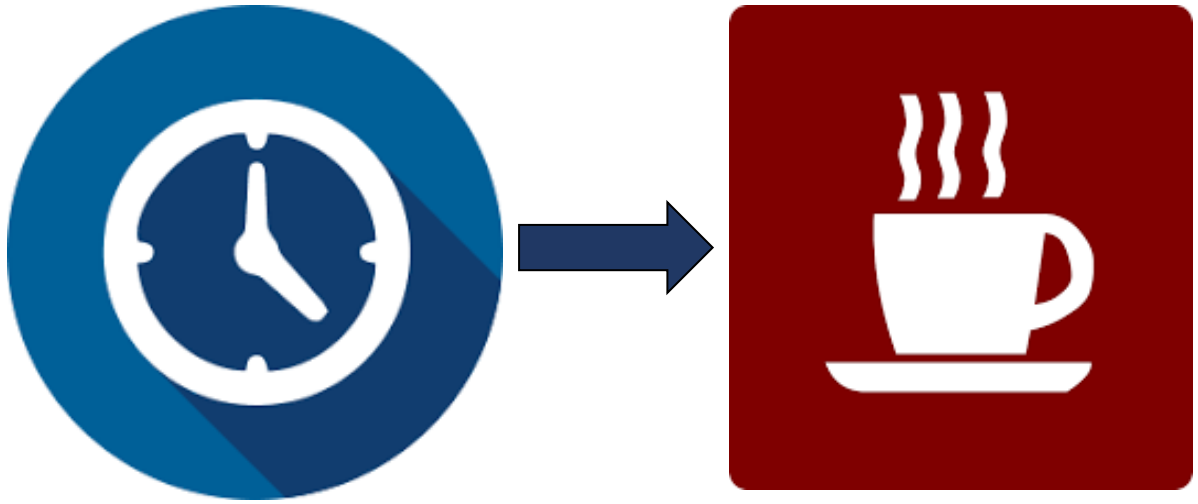
Contractor management failure

- Pathway 6: Work pressure
- The tyre handler required refuelling to respond to an urgent service request. Workers had difficulty obtaining fuel from the refuelling service crew in a timely manner.

- Pathway 8: Prior concerns:
- Also present

- <u>Actions after the incident:</u>
- The contractor provided a dedicated refuelling cart for tyre handlers. A mining company audit identified non-approved adaptors in use at other mines. Source: Jackson (2023)

Morning tea



Please be back in your seat ready to start in 30 minutes

West Australian mining industry fatalities profile

Review of the DMIRS Fatalities Register, by Jenke et al

- MSH_Data_FatalitiesHazardRegister.xlsx (live.com)
- Register covers the period from 2000 to 2018
- Includes details of 71 fatal incidents

West Australian mining industry fatalities 2000-2018

Occupation group	Number of fatalities
Fitters	**15**
Operators Underground	**13**
Operators Surface	**8**
Drivers Surface	**8**
Managers and Supervisors	**7**
Drillers and Blasters	**5**
Electricians	**5**
Service Workers	**3**
Trades	**3**
Professional and Technical	**4**
Process Workers	**0**
Occupational Health and Safety (OH&S)	**0**
Total - 12 Occupation Groups	**71**

West Australian mining industry fatalities profile

- 66% of fatal incidents included information regarding multiple Pathways.
- 18% of fatal incidents on the Register included information from just one Pathway.
- 15% of fatal incidents, no Pathway could be identified from the data and information from the register.
  - The ECU researchers allocated Pathways based on review of the information provided in the Register.

The 4 Key Pathways

4 pathways that are of specific interest:

- Pathway 1: Design, engineering, technical and maintenance flaws, has the second lowest score in the Roadshow surveys
- Pathway 4: Failures in safety management systems, was the second most common pathway on the register.
- Pathway 5: Failures in auditing, has the lowest score on the Roadshow surveys and is the 5th most common pathway identified on the fatalities register.
- Pathway 9: Poor management – worker communication and trust, was the third lowest mean in the Roadshow surveys.

The 4 Key Pathways

- Pathways 1 and 4 were also frequently identified as pattern failures in Quinlan’s systematic assessment across mining fatalities across 5 countries.

- This suggests that globally, organisations often have improvement opportunities in safe design and management systems.

The 4 Key Pathways: Implications for MSMS

Mines Safety Management System – WHS (Mines) Regulations

r 34: Duty to identify hazards

r 617: Managing risks to health and safety

r 621: Duty to establish and implement MSMS

r 622: Content of MSMS

r 623: Performance standards and audit

r 625: Review

The 4 Key Pathways: Implications for MSMS

What is a MSMS?

Most important new requirement under WHS (Mines) Regulations:

Processes and work methods that ensure the safe operation of a mine.

Framework that provides a systematic approach to the identification, assessment, management, control and communication of health and safety risks.

The 4 Key Pathways: Implications for MSMS

Mine Safety Management System (MSMS)

- Details of risk management process
- Systems, procedures, plans and processes developed for this purpose
- Management and supervisory structure
- Induction, information, training
- Supervision
- Resource allocation
- Contractor management

Principal Mining Hazard Management Plans

Emergency Plan

Health Management Plan

Radiation Management Plan

Underground Ventilation Management Plan

Ten Pathways and Mine Safety Management Systems

MSMS must be kept updated, to ensure it is effective to manage health and safety risks of current operations

- Review to keep current (not full system review – continuous improvement)
  - MSMS component review – triggers, reg 38, reg 618
  - Minor changes – incidents, audits, hazard reports, continuous improvement

Would you like cheese with that?

Ten Pathways and Mine Safety Management Systems

MSMS must be kept updated, to ensure it is effective to manage health and safety risks of current operations

- Review to keep current (not full system review – continuous improvement)
  - MSMS component review – triggers, reg 38, reg 618
  - Minor changes – incidents, audits, hazard reports, continuous improvement
- Review to ensure effectiveness (including control monitoring via KPI's)
  - Performance standards (Reg 623)
  - Audits
- System review – as a minimum every 3 years (Reg 625)
  - Management system review
  - Regulator notice

Ten Pathways and Mine Safety Management Systems

What is a Principal Mining Hazard?

- “Any activity, process, procedure, plant, structure, substance, situation or other circumstance relating to the carrying out of mining operations at the mine that has a reasonable potential to result in multiple deaths in a single incident or a series of recurring incidents”

Ten Pathways and Mine Safety Management Systems

The mine operator must;

- Identify all principal mining hazards at the mine;
- Conduct a risk assessment that involves a comprehensive and systematic investigation and analysis of all aspects of risk to health and safety associated with the principal mining hazard;
- Consider the principal mining hazard individually and also cumulatively with other hazards at the mine.

- Links directly to the Ten Pathways concept
  - As evidenced in the following Case Studies

Further analysis via the Ten Pathways

Case Studies:

- Beaconsfield underground mine (2006)
- Cadia East mine (2010)
- Pike River underground mine (2010)
- Ravensworth (2011 and 2013)

Beaconsfield (Tasmania)

Underground rock fall, (2006) single fatality, 2 workers trapped

Path way	Description	Path way	Description
1	**Present** (inadequate ground support identified; change in mining method failed to arrest falls. Rising seismicity in mine)	6	**?** (mine under pressure, but unproved -see Goh et al 2012)
2	**Present** (Jan 2004 to April 2006 24 recorded rock falls - 1 over 50 tons every 10 weeks & 6 in 2006)	7	**Present** (laws inadequate & inspectorate seriously under-resourced)
3	**Present** (no assessment of ground support after Oct 2005)	8	**Present** (3 of 4 underground supervisors & some experienced miners expressed prior safety concerns. Trapped worker Todd considered leaving mine Xmas 2005).
4	**Present** (over-reliance on behaviour based safety and poor feedback loops)	9	**Present** (Safety committee (ineffective), no SHRs & considerable mistrust)
5	**Present** (some audit recommendations ignored)	10	**Present** (Good - indeed was considered a major success)

Cadia East (Orange, NSW)

Inrush (2010) no fatalities, 7 workers exposed to inundation risk

Pathway	Description
1	**Present** (Failure to implement a barrier to prevent water entering the shaft and failed to drill tell-tale holes to monitor water build-up in the shaft as recommended by regulatory guidance. •Lack of engineering rigour in monitoring - the slurry flowing from the base of the shaft was not reviewed by an engineer. • Reconciliation did not consider the weight of wet material)
2	**Present** (The cuttings mixed with water formed a slurry that appeared to flow continuously down the drive leading management to presume this would continue and was unlikely to build up to block the bottom of the shaft.
3	**Present** (RA on a previous raisebore shaft was not updated when an aquifer was intersected and did not address the risk posed by wet reamed material. • While the RA did identify the risk of potential inrush from a blocked shaft the residual risk was classified as insignificant and rare. • RA failed to identify risk - there was no assessment of catastrophic failure of the material pile and subsequent inrush potential and failed to identify the build-up of water in the shaft once it was blocked. • Informal RA failure - mine documents that addressed the potential of inrush advocated the use of a remote-control bogger. • The supervisor who completed the JSEA failed to comprehend that water flowing from the shaft base signified a choke and did not include the use of a remote control bogger as a means of reducing the risk or implement an exclusion zone)

Cadia East (Orange, NSW)

Inrush (2010) no fatalities, 7 workers exposed to inundation risk

Pathway	Description
5	**Present** (There were several verbal reports that the material had blocked the shaft. A supervisor informed mine management of the blocked shaft by telephone. After this discussion, management instructed the supervisor to bog up to the brow rather than carry out an engineering assessment. (some audit recommendations ignored)
4, 6, 7, 8, 9 & 10	All 6 of these pathways were present. Note that **all 10** Pathways were identified as having contributed to the accident.

Pike River (New Zealand)

Underground coal mine explosion (2010), 29 fatalities

Path way	Description	Path way	Description
1	**Present** (Routine methane exceedances and main ventilation fan located underground, early geological report highlighted problems)	6	**Present** (Mine in financial trouble, never got close to production targets & bonus system encouraged risk-taking)
2	**Present** (Exceedances known and also safety concerns reported informally to Board)	7	**Present** (Laws manifestly inadequate, inspectorate under-resourced/inadequate expertise/targeting & no chief mines inspector)
3	**Present** (Critical gaps in risk assessment eg location of fan, hydro mining)	8	**Present** concerns expressed prior, Hydro-mining consultant left over concerns)
4	**Present** (Flaws in OHSMS including unaddressed concerns)	9	**Present** (Union threatened for backing supervisor who led crew out of mine due to safety concerns)
5	**Present** (No adequate audit of mine systems done prior to incident)	10	**Present** (Only second egress was ventilation shaft (inadequate) and destruction of ventilation fan hampered any possible rescue efforts)

Ravensworth (NSW)

2 single fatality events (2010 and 2013)

Reject bin door failure & heavy/light vehicle collision

Pathway	Description
1	**Present** (2009 Software controlling automated opening reject bin door failure; • 2013 Traffic management plan deficiencies (windrow heights, intersection design, grades and crossfalls contribute to water ponding)
2	**Present** (2009 Inspector noted 5 prior incidents (unplanned movements of door • 2013 Investigation identified 11 prior incidents - near misses/minor collisions • 19/1/2011 – 17/10/2013 & November presentation on heavy vehicle interactions emphasised behaviour/administrative controls)
3	**Present** (2013 prior risk assessment identified collision risk due to communication & vision issue (some reference to wet conditions but not night combination) including perception error due to building lights and ponding)

Ravensworth

2 single fatality events (2010 and 2013)

Reject bin door failure & heavy/light vehicle collision

Pathway	Description
4	Present (2009 Error in SOP undetected, safety critical information not passed on to software designer • 2013 both drivers hired in last 12 months and undergoing competency training. • Heavy Vehicle driver just assessed as competent on bigger Caterpillar 793D haul dump truck (first shift at night after rain).
5	**Present** (2013 audit didn't consider higher order controls (vehicle separation)
6	**Present** (2013 mine aware significant expansion of production challenged resources, training, processes)

Corroborating evidence

- Western Australian mining industry study (Jenke et al 2022) using both incident analysis and workforce survey confirmed 10 pathways and argued should be used as both to guide incident investigation and as a checklist audit tool.

- Pattern causes apply to single fatalities and multiple fatalities. Confirmed by Jenke et al WA study (2021) and Newcastle University PhD examining 51 serious mine coal and metalliferous mine incidents (Jackson, 2021 & article in press).

- Jackson found some of the 10 pathways present in every incident examined.
  - The lowest number was 2 (outlier) but vast majority (75%) had 5-7 pathways and significant minority (25%) had 8-10.
  - Noted limitations in regulator investigations (failed to consider particular pathways or skated issues like worker views and production pressures)

Corroborating evidence

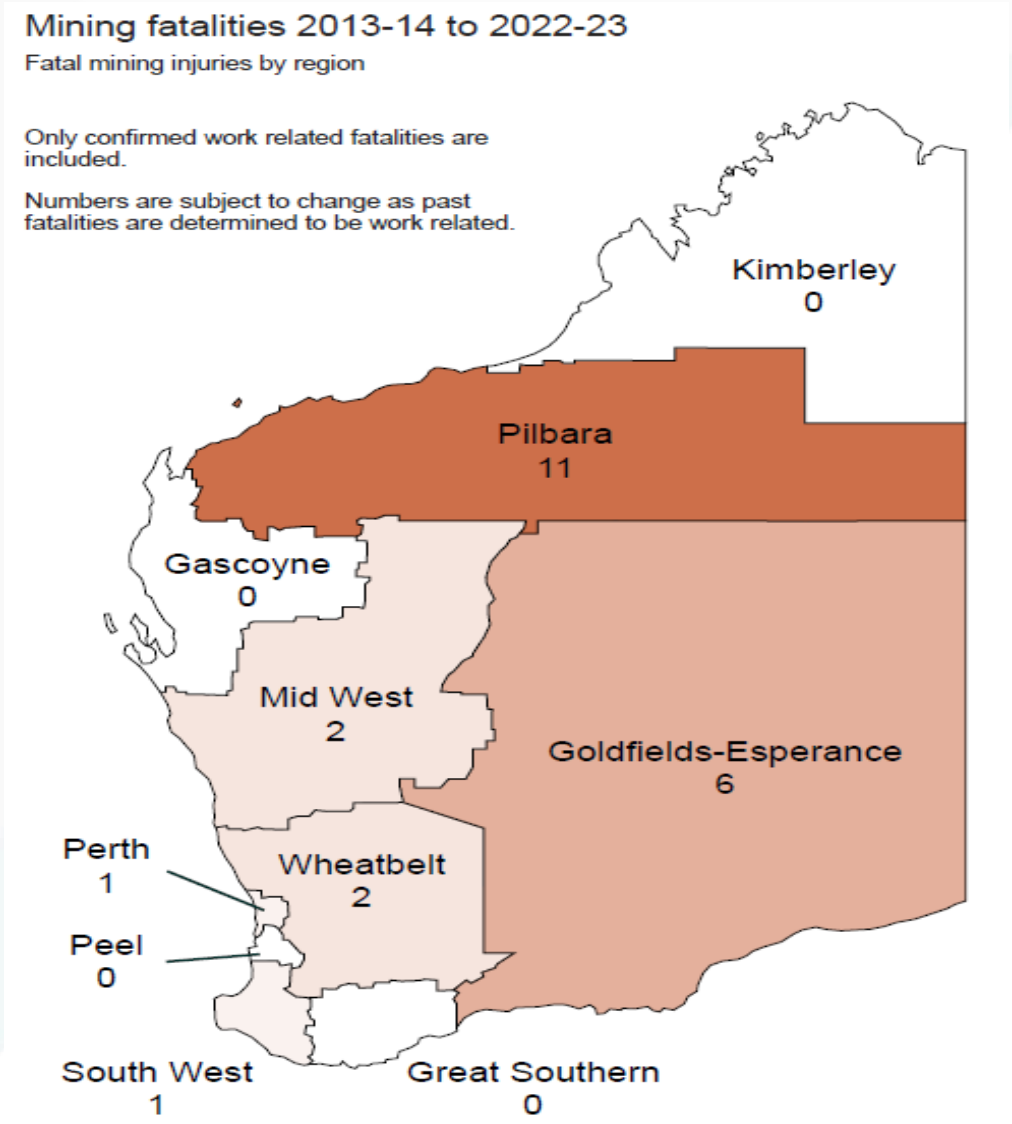
- Many observations of practical use in Jackson study (eg breakdown of information flows during shift changes)
- Jackson found companies too readily turned to **behavioural** controls rather than **engineering/system** remedies even though the former are prone to failure and indeed more susceptible to production/cost pressures

Recent (post-2018) data

- 9 fatal accidents (single fatalities) from 2019 to 30th June 2023
  - 3 other cases under analysis re: workplace v natural causes
  - 1 rail fatality on a mining lease

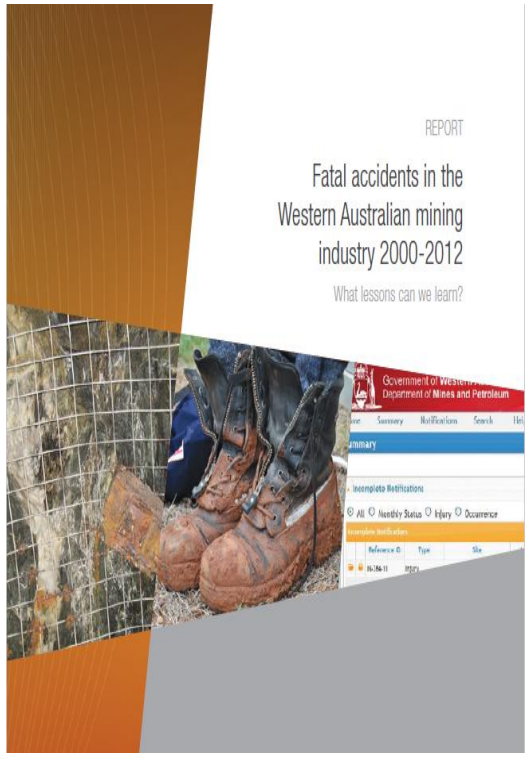
- 6 occurred on surface operations
- 3 occurred in underground operations
- Summaries can be found on the internet, but important to note that contributing factors for most cases are still being evaluated.

Where did the recent fatalities occur?



Region	Fatalities per million hours
Kimberley	0
Pilbara	0.010
Gascoyne	0
Mid West	0.016
Goldfields- Esperance	0.013
Wheatbelt	0.032
Perth	0.019
Peel	0
South West	0.011
Great Southern	0

The statistics keep being affirmed



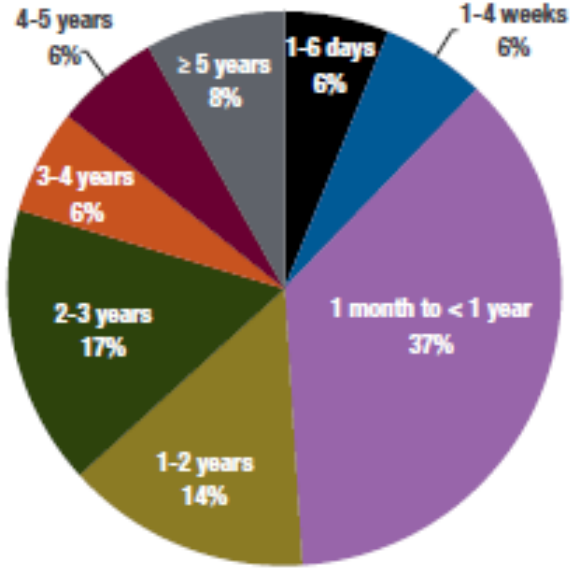


Figure 3 Duration of deceased person at the mine as a percentage of total fatalities [sample size = 49]

49% of all fatal accidents involved persons who had been on the minesite less than 12 months

66% of all fatal accidents involved persons who had been supervised by a supervisor with less than 2 years experience

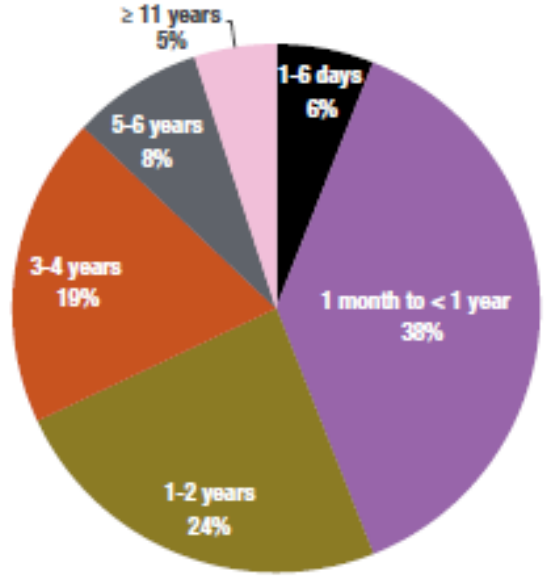


Figure 4 Duration of person undertaking supervisor's role as a percentage of total fatalities [sample size = 37]

Your turn to tell us – What has changed since 2019?

1. Engineering, design and maintenance flaws
2. Failure to heed warning signs
3. Flaws in risk assessments
4. Flaws in management systems
5. Flaws in system auditing
6. Economic and reward pressures compromising safety
7. Failures in regulatory oversight
8. Worker or supervisor concerns that were ignored
9. Poor worker-management communication and trust
10. Deficiencies in emergency and rescue procedures

How many of the 10 Pathways do you think currently exist as flaws in your workplace?

Break out exercise: Part 2

- In your groups:
- Ask your fellow table members to tell you which pathway they scored the **lowest** and **why**:

Break out exercise: Part 3

- What (if any) are the recurring themes?
- Please use Slido to list any recurring themes that were identified.

Concluding Commentary

Near-miss disaster: Grosvenor coalmine explosion May 2020

Path way	Description	Path way	Description
1	Methane drainage prior to incident inadequately monitored/managed (BOI). Source of ignition still being debated post BOI.	6	mining operations repeatedly conducted in a manner where gas emissions generated by rate of production in exceeded mine's gas drainage system capacity (BOI)
2	Pattern of gas exceedance for some time prior	7	Inspection regime tended to accept management reassurances/some disorganisation (visits/record coordination)
3	BOI found number of failures to risk asses gas exceedances as conditions changed	8	
4	OHSM regime weakened by extensive use of labour hire especially report back mechanism	9	Labour hire workforce afraid to report issues & union input marginalised (eg electronic exchange of inspection reports). Some issues raised ignored
5	BOI identified number of auditing failures & recommended improvements	10	rescue worked but serendipitous as anaesthetist vising town on day able to stabilise miners so could be airlifted to hospital with burns unit

Concluding Commentary

Near-miss disaster: Grosvenor coalmine explosion May 2020

Worker voice matters:

Wayne Sellars was one of five coalminers severely burned in the May 2020 Grosvenor coalmine explosion.

Fear of victimisation – all injured were labour hire workers and he was the only one to give evidence to the Board of Inquiry

Lessons for prevention

- Pattern causes go long way to explaining recurrent fatal work incidents. Can be used as auditing/investigative tool & assessment checklist. Focusing on them would minimise fatalities. In particular:
  - It is critical to vigorously audit principal hazard and other management plans to detect and correct corrosion of risk controls.
  - This will make your systems more robust, assist the inspectorate and enable it to make better use of its resources.

  - Systems as hierarchies of control corrode over time.
  - Guarding against this requires careful auditing, multi-party engagement & valuing constructive dissent.

Lessons for prevention

- Pattern causes apply to single fatalities and multiple fatalities - both low frequency/ high impact events (routine injuries too?).

- Pattern causes are latent failures, any one could cause fatal incidents but more you have more likely. Immediate trigger event often minor of itself and difficult to predict/target.

- Changes to work organisation like subcontracting/agency work can weaken OHSM

Some more lessons for prevention

- Safety ‘culture’ was not a pattern cause rather symptom of failure in OHS management regime and priorities informing monitoring, incident reporting & investigation (effective HPI reporting critical) and strengthening auditing requirements

- Mutually reinforcing multiple feedback loops to identify failures/ensure constructive dialogue (potential for different/critical views)

- Problem solving and focus on upstream solutions (design/engineering/exposure). Some companies now targeting single fatalities, focus on fatality mechanisms, pattern causes, involvement and upstream (eg. engineering) remedies

Some more lessons for prevention

- Need to step back periodically ask big questions or risk series of decisions will slip into death/disaster.
- Experience of managers, safety reps and inspectors needs to be valued.
- Boards must consider and be held accountable for safety implications of decisions.
- When investigating incident or HPI ask questions in relation to 10 pathways – even ruling some out is important learning and will make for more comprehensive report/understanding.
- Not learning from failure is a form of insanity (10 pathways applies to other high hazard industries ie model of why/how human organisation fail but need to understand all hazards relevant to each industry - cannot do risk assessment without this.

WA mining – tools to help you

- Code of Practice on Mine Safety Management Systems
  - Code of practice - Mine Safety Management System | Department of Mines, Industry Regulation and Safety (commerce.wa.gov.au)
- Code of Practice on Emergency management for WA mines
  - https://www.dmp.wa.gov.au/Documents/Safety/MSH_COP_EmergencyManagement.pdf
- Emergency management audit
  - https://www.dmp.wa.gov.au/Documents/Safety/MSH_AuditGuide_EM.pdf

To help you collect your own Pathways data

- Edith Cowan University has built an on-line version of the 10 Pathways analysis we have just completed.

[10 Pathways survey (qualtrics.com)]

The (anonymous) data will be collected and analysed by ECU.

A few thank you’s

- To Emeritus Professor Michael Quinlan, Inspector Peter Nissen and our DMIRS colleagues, thank you for your contributions today
- To everyone in the audience, thank you for your attendance, your feedback and eager participation in our workshop exercises.
- To all the Safety and Health Representatives in the room – thank you for standing up to be counted for improving WHS in your workplace
  - The inspectorate recognises your role, appreciates your endeavours and is willing to provide support where needed

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Links to Publications Cited in Today's Programme

- You can find the Edith Cowan University research, lead authored by Tanya Jenke at:
- https://doi.org/10.1016/j.ssci.2021.105494

- The Fatalities Register can be found at:
- MSH_Data_FatalitiesHazardRegister.xlsx (live.com)

- Just in case you want to read more of Prof. Quinlan's research, here's a link to his book
- Ten Pathways to Death and Disaster, Learning from Fatal Incidents in Mines and Other High Hazard Workplaces by Michael Quinlan | 9781862879775 | Booktopia

- Emeritus Professor Michael Quinlan UNSW PhD FASSA (Launceston Tasmania) m.quinlan@unsw.edu.au

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