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Emerging and re-emerging occupational illness and disease surveillance, monitoring, and foresight: *An evidence and practice review supplemented by 10 evidence profiles*

Report

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EXECUTIVE SUMMARY

PROJECT QUESTIONS

WorkSafe Victoria commissioned a project exploring the following questions:

1.1. What is the evidence regarding any potential for re-emergence or significant increase of known disease and illness issues?

1.2. Is there emerging evidence regarding new disease and illnesses linked or related to work practices?

1.3. Are there new risk control options to reduce harm from occupational illness and disease?

2.1. Are there new and emerging data sources for disease markers to assist public health monitoring for workplace safety in next five years and beyond?

2.2. Are there any new systems and/or emerging means of monitoring for workplace safety?

METHODS

A suite of bespoke methodologies was developed to respond to the above questions:

- A practice review involving 8 interviews with experts.
- A series of 10 topic profiles (brief snapshots of recent, subjectively-selected peer-reviewed evidence to provide a sense of the current state of evidence on the topic).
- A rapid evidence review focused on a subset of emerging surveillance and monitoring tools being used for a category of diseases, for instance, Artificial Intelligence (AI) and big data for zoonotic disease surveillance.

SUMMARY OF PRACTICE REVIEW FINDINGS

Eight interviews were undertaken with experts with backgrounds in medicine, public health/epidemiology, occupational hygiene, economics, and a range of construction trades. The interviewees had diverse and valuable experiences working in academia, private industry, industry associations, and government.

Emerging and re-emerging occupational illnesses and diseases

The following categories of emerging and re-emerging illnesses and diseases were highlighted by participants:

- Communicable/Infectious diseases, including zoonotic diseases.
- Respiratory illnesses and diseases most notably occupational asthma.
- Illnesses and diseases related to chemical/nanoparticle exposures.
- Dermatological issues like contact dermatitis.
- Mental health conditions.

Surveillance and monitoring

Data linkage and better utilisation of existing data sets

- Several participants felt that there are growing opportunities to link data sets, for instance by connecting data about workplace illness and climate.
- Several participants also felt that better use of existing data sets was merited, noting that we could better capitalise on the nuance present in large administrative datasets (e.g. the PBS).
- They also highlighted several ethics and access issues related to compiling large data sets containing sensitive data.

Cohort studies and registries

- Several participants underlined the value of well-supported cohort studies and registries, but that the value of these tools can usually only be realised with sufficient resourcing.

Health assessment in key exposure settings/industries

- Health assessments at regular intervals in high-risk industries and exposure locations were also mentioned as a strategy that should be used more frequently. This approach could possibly be accomplished through regulation in some cases.

Human intelligence

- Multiple participants felt that networks of knowledgeable health practitioners and workers could be better developed and utilised to know what is going on "on the ground".

Artificial intelligence techniques

- Artificial intelligence was mentioned less frequently than anticipated, and when it was, it was usually mentioned as a validated tool to support diagnostics in some fields.

New monitoring devices, including wearables

- Multiple participants mentioned exposure monitoring devices or bio-monitoring devices, but indicated that many are only mature enough to be used as supplements to more validated tools.

Key risk mitigation strategies

Key themes about risk mitigation were:

- Several participants felt that better assessments of risks related to new product life cycles (e.g. increasing re-use and re-purposing of some materials) was an important consideration.
- Considering how return to work can be included in holistic health considerations.
- Training more workers in occupational hygiene.

Occupational Illness and Diseases Profiles

It is not feasible to summarise the insights from profiles on 10 distinct topics here. Please look at the key findings at the top of each profile for a bullet point summary. The profiles were on the following topics:

- Chemical exposure and miscarriages in healthcare workers
- Encephalitis (with a focus on the impact of climate change)
- Malaria (with a focus on the impact of climate change)
- Occupational asthma
- Occupational heat stress
- Poor air quality resulting from bushfires and risk controls for the workplace
- Ross River Virus
- Secondary mental injury as a result of occupational injury
- Silicosis outside of construction, manufacturing and mining
- Work-related chronic obstructive pulmonary disease

Summary of rapid review key findings (focused on AI, Big Data and Zoonotic Diseases)

The rapid review identified 3 reviews and 6 primary studies that find promising evidence of the following:

- Machine learning is being used to better predict zoonotic disease dynamics that may be relevant to the workplace.
- Machine learning and big data are being used to support better prevention of zoonotic disease spread in settings relevant to many workers.
- Machine learning and big data can be used to personalise insights for individuals.
- Participatory approaches can enhance the quality of surveillance.

The review also uncovered some key risks, limitations and challenges related to AI and big data for surveillance of zoonotic diseases:

- As with other quantitative approaches, insights are only as good as the data on which they are based, and issues can be magnified when compiling large datasets.
- Linking dataset come with legal and privacy concerns.
- Making linkages between zoonotic surveillance and occupational settings may require changing how some data are collected and structured to effectively link data.
- Building the infrastructure for using these tools well may require significant up-front investments.

Cross-cutting themes

Based on the three methods of data collection undertaken, a few cross-cutting themes emerged:

- Key emerging and re-emerging illnesses, diseases, and issues included contact dermatitis, occupational asthma, welding fumes exposure, zoonotic diseases, and mental health issues.
  - ***Potential implications for practice:*** Regulators, unions, peak bodies, or other workers groups could fund, organise, and/or implement tailored occupational hygiene trainings for workers in high-risk sectors or in sectors where emerging issues may be present.
  - Moreover, regulators could develop awareness raising materials, guides for occupational history taking, or other outreach approaches for general practitioners and other relevant health professionals in an effort to identify emerging and re-emerging occupational illnesses and diseases identified earlier in this Executive Summary.
  - Regulators and researchers collaborating to ensure that linkages between existing health-related databases and those from other relevant topics (e.g. climate) are being used maximally to identify emerging and re-emerging occupational illnesses and diseases may be a useful near-term step.
  - Regulators, medical providers, unions, peak bodies, and other workers' groups could develop knowledge exchange activities to consolidate learning about the growing burden of mental health conditions caused by occupational factors, as well as how the changing nature of work may be affecting this emerging issue.
- Climate change is going to shape a number of occupational illnesses and diseases in complex ways.
  - ***Potential implications for practice:*** Regulators and researchers collaborating to ensure that linkages between existing climate and health-related databases are being used maximally to identify emerging and re-emerging occupational illnesses and diseases may be a useful near-term step.

- Big data and machine learning are creating several new opportunities for surveillance.
    - ***Potential implications for practice:*** Regulators could maintain awareness of the capabilities of AI tools for data processes and the development of insights and deploy them where appropriate within a well-designed ethical/responsible AI framework.
    - Additionally, regulators, researchers, and other stewards and stakeholders of data can explore partnership opportunities to exchange knowledge about valuable data sets, as well as develop ways to increase the value of data linkage where possible. For instance, regulators developing a closer understanding of if and how Pharmaceutical Benefits Scheme data could support their role in the community may be an action easily realised in the near term.
- Long-term planning, engagement, and support is required.
    - ***Potential implications for practice:*** Regulators, government research funding schemes, private businesses, and/or universities could develop funding opportunities and research infrastructure that ensures that on-going and/or long-term research is possible. For instance, if a cohort study is initiated through government funding, ensuring that the funding is allocated for a sufficiently long period for the cohort study to realise its value to the community.
- Sensing and monitoring technology are getting a lot better, but still need further improvement and validation in many cases.
    - ***Potential implications for practice:*** Researchers or regulators regularly undertaking monitoring for updates on potential use cases of and validity of data from new sensors could support the process of integrating them into health and safety practices more efficiently.
- Collaboration across sectors and disciplines is key.
    - ***Potential implications for practice:*** In relation to illnesses that may require substantial cross sectorial collaboration, for example in relation to mosquito-borne infectious diseases, developing or bolstering systems for knowledge sharing, coordination, and shared action between all potentially relevant actors could help to support early identification of emerging issues and holistic mitigation and response efforts. Systems-thinking-related methods like stakeholder mapping could be used to ensure that all relevant actors are identified and engaged.
- Greater awareness of occupational illnesses and diseases among workers and healthcare providers would help identify problems while they are still modest in size.
    - ***Potential implications for practice:*** Similar to the above implication under "Contact dermatitis…" regulators, unions, peak bodies, or other workers groups could fund, organise, and/or implement tailored occupational hygiene trainings for workers in high-risk sectors or in sectors where emerging issues may be present (e.g. outdoor workers in relation to mosquito-borne illnesses, high stress office environments in relation to mental health disorders, or specific areas of the building sector in relation to exposure to new materials).
    - Moreover, regulators could develop awareness raising materials, guides for occupational history taking, or other outreach approaches for general practitioners and other relevant health professionals in an effort to identify emerging and re-emerging occupational illnesses and diseases identified earlier in this Executive Summary.

SUMMARY OF REGULATOR TAKE AWAYS

- There is a need to investigate opportunities for data compilation and harmonisation and data linkage, and the possibility of harnessing the power and value or AI/machine learning to better monitor emerging illnesses.
- Adequate funding of longitudinal cohort studies of high-risk workers is necessary to monitor illnesses, both in terms of their prevalence and their outcomes.
- Education of both healthcare professionals and workers on the link between work conditions and illness and occupational hygiene would be valuable for managing risks and monitoring emerging illnesses.
- Emerging technologies such as wearable devices should be considered as tools that can support workers safety.

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BACKGROUND

A responsive regulatory model requires a holistic response to treating harms at the individual, workplace and industry level, responding to issues before and as they arise while also working to drive systemic change. WorkSafe Victoria's response to the artificial stone benchtop silicosis outbreak identified *proactively identifying and monitoring early indicators of potential occupational illness and diseases issues* prior to their emergence as key to implementing controls and developing interventions for known and potentially emerging hazards.

Occupational illnesses and diseases often affect workers who are less experienced, especially younger workers and apprentices, casual hires and temporary workers including culturally and linguistically diverse workers, who generally have lower awareness of the risks of exposure to hazards (e.g. such as silica dust), and less confidence in questioning workplace processes and directions, even in jurisdictions that actively promote health and safety issues. These challenges require a considered systematic approach to public health screening, data review, and literature analysis to detect changes in population health so as to provide early indicators of potential emergence of workplace hazards.

Whilst WorkSafe Victoria accesses data for several focus hazards – silica, asbestos, lead, welding fumes, noise – often these have significant lag and there are many other emerging local and global information sources on hazards and emerging industry practices for which WorkSafe Victoria does not yet have sufficient systematised information awareness, connectivity, and access. Additionally global academic literature and health reporting also provides a rich source of early information. For example, in the case of the re-emergence of silicosis associated with benchtop fabrication, there were initial reports of cases suggesting an industry issue over a number of years (Pascual et al., 2011; Kramer et al., 2012; Bartoli et al., 2012; Frankel, Blake & Yates, 2015) prior to regulatory response and the disease manifestation challenged traditional screening approaches (Hoy et al., 2023).

Despite progress in occupational health and safety measures that has reduced the incidence or work-related injury and illness, new hazards continuously emerge alongside shifting work practices and technologies, and certain diseases once thought controlled or eradicated may resurface due to changing environmental factors or inadequate preventive measures. With recent developments in relation to data sources for monitoring occupational diseases like the National Occupational Respiratory Disease Registry, it is an opportune moment to gain a nuanced understanding about how such new data sources, as well as advancements in surveillance approaches, might help to understand new emerging and re-emerging occupational illnesses and diseases.

The ability to identify systems, sources and data on emerging risks and issues through structured information, data and data source horizon scanning will enable WorkSafe to develop and adopt pre-emptive proactive systems, controls and interventions for occupational illness and disease. Broad horizon scanning to establish systems with robust dynamic data and intelligence sources will provide a knowledge platform to actively identify issues and opportunities to prevent and minimise harms from new, emerging, and existing occupational health hazards arising from societal changes.

To this end, WorkSafe Victoria commissioned a project exploring the following questions.

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A suite of bespoke methodologies were developed to respond to the above questions:

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- A rapid evidence review focused on a subset of emerging surveillance and monitoring tools being used for a category of diseases (AI and big data for zoonotic disease surveillance.

Details about each of these methods will be described in the relevant section of the report.

PRACTICE REVIEW (EXPERT INTERVIEWS)

BACKGROUND

In the commissioning process, Monash University advised that key informant interviews, referred to here as a practice review, may benefit the project's ability to respond broadly to the research questions and link the narratives from the other two components of the research. WorkSafe Victoria agreed with this advice and included a practice review in the project.

METHODS

The Monash University team gained ethical approval from the Monash University Human Research Ethics Committee under project number 30009. Appendices 1-3 contain key ethics documentation including the interview guide, explanatory statement, and consent form.

Potential participants were identified through several sources, including professional contacts from WorkSafe Victoria, Monash University Health Working Lives, and the Evidence Review Service; as well as through searches on the open internet for experts in this field. In cases where professional contacts' contact details were not publicly available, collaborators sought consent from potential participants before sharing their contact details with the research team. Lastly, snowball sampling was used to identify additional participants through a question at the end of each interview. Beyond the identification of potential participants, the Monash University Evidence Review Service managed all aspects of the practice review. The participants have been anonymised in accordance with the ethics approval.

Table 1. Participant profiles

Participant #	Profile
1	An economist who undertakes research primarily on topics where issues of labour, health, and the environment meet.
2	A medical doctor with training in occupational health and epidemiology. Has held academic roles, but also has maintained a clinical practice.
3	A medical doctor who specialises in occupational and environmental health. Has held senior academic roles, as well as board, editor, and/or advisory roles for several relevant professional associations, journals, and regulators.
4	An occupational hygienist and epidemiologist with an extensive research track record on a wide range of occupational illnesses and diseases.
5	An academic who spent more than a decade working in environmental health for local governments or in private industry prior to undertaking doctoral level qualifications.
6	The occupational health and safety lead of a large professional association who previously spent several years working in fields like road construction.
7	A respiratory physician with specialist knowledge of both research and clinical practice related to occupational lung disease, as well as occupational disease and illness surveillance more broadly.
8	An epidemiologist working in government

Interviews were undertaken by the Monash University Evidence Review Service using a semi-structured interview guide. All but one interview participant used the online version of the consent form, the remaining participant returned a signed digital copy. All interviews were undertaken using Zoom and recorded with the consent of the participants. The recordings were transcribed. The transcripts were thematically analysed (Braun & Clarke, using NVivo (2022, 1.7.2) software and an inductively developed coding framework was informed by the research questions.

The findings are summarised below.

FINDINGS

Emerging or re-emerging illnesses and diseases

Sub-headings with an * are subjects that are also included in the evidence profiles above. It should also be noted subheadings in this section were developed in inductively and primarily focus on categories of illnesses and diseases, but may also focus on key exposures or workplace settings.

Communicable/Infectious diseases*

Several participants spoke about a broad need to maintain awareness of known and emerging communicable diseases, however most did not identify specific illnesses on which to focus.

> "… infectious disease is probably the big one that comes to mind [and it is] not just an occupational problem…"
>
> - Participant 2

Some participants said that norms related to attending work with cold- and flu-like symptoms needed to change and that lessons from the COVID-19 pandemic could be better carried forward in workplace expectations and workers' behaviours.

> "And a lot of the time we don't want people to take time to leave. We don't want people to stay at home…we tend to sort of downplay the occurrence of people having a flu or cold. And we don't realise that these type of diseases, they can have serious impact on some people, they affect people differently…If you tell your boss you're not coming to work, you have a flu because you have a cold, they might see you as somebody who's not serious…I think the workplace should start putting those policies in place…"
>
> - Participant 5

One participant who is well appraised of workplace dynamics in several trades felt that many employers needed to take risks of zoonotic diseases more seriously by providing better guidance and support for workers.

> "…we're pushing for potential vaccinations or at least a risk assessment into it for road maintenance workers. [Employers] were laughing at us because these guys, you have to pull off sometimes removing up to 200 kangaroos on a freeway…we've spoken about with sheep shearers and other industries [too]…there [is sometimes] no procedure or process…"
>
> - Participant 6

Another participant indicated that undertaking surveillance of mosquito populations is likely one of the most cost-effective ways to anticipate future threats of several zoonotic diseases.

> "I think the mosquito surveillance would be the most cost effective way…"
>
> - Participant 8

Climate change-related matters*

Directly related to the above comment about zoonotic disease risk, one participant highlighted that climate change will change the dynamics related to vector borne diseases.

> "…in the last couple of years I think there was this outbreak of, I'm not sure if it was Japanese encephalitis or some kind of Murray Valley disease or something that's kind of related to mosquitoes and they wouldn't normally go in certain areas. So these kind of vector borne diseases… can change as the climate changes..."
>
> - Participant 1

More broadly, several participants noted that there are a wide range of variables that are going to shift as a result of climate change.

> "Climate change is going to have a big impact on heat, particularly in this country. And external work in the building industry, for example, is going to be problematic. So I think heat related illnesses [is finally on the] radar… it's quite a complicated…because there are so many variables around it, like work rate, the actual temperature, the humidity, the wind speed, the shade, or not hydration. And then there's an enormous variability in people's individual responses to heat. So depending on whether they're fat or thin, for example, what drugs they're taking…pre-existing illnesses…"
>
> - Participant 4

Risk mitigation practices are also made more complex by climate change. One participant indicated that wearing some forms of personal protective equipment to manage one risk, undermine comfort or managing heat related risks.

> "…[there are some limitations]…first page [of an OHS training manual] is a picture of a worker looking like Christmas tree…they've the ear masks, they've got the face mask and this thermal stuff. [In my road construction work] I wore a negative pressure respirator and [my colleagues would say] what [are] you doing mate?…you try to swing an asphalt with 170 degree products in outdoors, 30 plus degrees, hot machinery, you've got long sleeves, hard hat…"
>
> - Participant 6

Respiratory diseases like silicosis and pneumoconiosis*

A number of respiratory illnesses were highlighted across the participants. The recent national and international discussions about silicosis were often at the front of mind for participants.

> "I think pneumoconiosis is still a major issue. Even with the ban on artificial stone, there are lots of other sources of silica exposure. We still have a lot of coal mine dust exposure throughout the country. And I think welding fumes is a bit of a sleeper as well with respiratory disease as well."
>
> - Participant 3

The lessons from recent experience with silicosis were often cited as being useful for the wider conversation about identifying emerging and re-emerging diseases and illnesses. Understanding the full lifecycle of products that pose health risks, as well as the potential exposure of people adjacent to worksites were common themes.

"I suppose what we need is a lens that says what's changing? What's changing in terms of things we're using or processing or new products. So what's foreseeable when you start doing that?"

- Participant 4

"It's really how they're used… the waste was a problem because the hygiene conditions in these workplaces is not that good. The cleanup of [engineered stone] dust wasn't good. We've got cases of people in offices in a corner of the workshop who are in sort of administrative people. They're walking through the workshop, dust is getting into their little cubicle in one corner of the workshop. So they're still having quite substantial exposure. So it's not [people working directly with products], it's neighbourhood workers as well..."

- Participant 3

With silica dust exposure, the complexities of understanding and mitigating risk were underlined by more than one participant.

"…there's a lot of things that affect silica…for example, coal seams, which are wider here than in the us. So you get more silica involved in coal cutting in the US Appalachian region than you do here….you also get changes in technology…you've now got these big cutting machines that just go across the whole face. And then they used to have those as unidirectional and you could control the airflow. Now they have the bidirectional, so you've got it coming back in both directions…it varies from place to place depending on what you're doing. And the technology you use will also vary the amount of exposure there is."

- Participant 4

Small and medium enterprises were often mentioned as places in which there may be less knowledge about exposure risks and where there might be less mature risk mitigation efforts in place.

"A lot of small and medium enterprises could have helped prevent [the number of silicosis cases that are now being found]."

- Participant 3

Occupational asthma*

Occupational asthma was so frequently mentioned that it merits its own subheading. Both medical specialist and non-specialist participants highlighted occupational asthma as being common, important, and under-recognised.

"…to me it's work-related asthma, which is asthma that's either caused by work exposures or has been worsened by workplace exposures…in middle to high income countries work-related asthma is the most common occupational lung disease there is. In Australia, we haven't been really identifying work-related asthma as well as a lot of other countries have."

- Participant 7

"…I wouldn't say is a new or re-emerging. It's just a continuing issue that's probably not recognised well enough and is important because if it is picked up, it can make a difference between somebody who hasn't been asthmatic, who's developed occupational asthma, but can then go on to become asthmatic in general if they're not removed from the exposure."

- Participant 2

"….I think that's probably an underestimate. I think there are a lot of people out there who develop asthma later in life, and it's missed. [Treating medical professionals] just don't ask about work…[Sometimes workers] can't cope with the respiratory protective equipment. They get triggers off attacks, and they leave the industry and go into something else. I think that happens a lot, especially in small and medium sized industries."

- Participant 3

"…you've got people [with] occupational asthma, so they get moved [to] a different area, but it's just, it's been that way forever that okay, you got asthma now. Okay, well you can't work in there anymore [so you get moved to a different work space]…[but we should be asking] why [are] they getting asthma?"

- Participant 6

Cancer

A few participants mentioned cancers potentially resulting from a range of exposures – most of them mentioned lung cancer specifically.

Most also noted that the link between lung cancer and an occupational exposure is often not made.

"…I think lung cancer is underdiagnosed in terms of its relationship with work. Not that the cancer is undiagnosed, but the relationship with work, I think is unrecognised on the whole, silica is a respiratory carcinogen, so is asbestos."

- Participant 3

More than one participant said doing better to control exposures is critical.

"…we've been out in the workplace taking measurements and watching what people do. And I've been very surprised at shouldn't have enter surprised, I guess. But it applies that the lack of control of exposures that ought to be well controlled."

- Participant 2

Chemical/nanoparticle exposures*

Several participants raised the fact that there are several professions in which workers may be exposed to dangerous levels of chemicals with known and unknown effects. High turnover in the professions or lack of knowledge about the specific performance and effects of some substances were highlighted.

"Hairdressers…They use a lot of chemicals, sensitising chemicals in their work, and young in particular will leave the industry doing the job that they really like and they have to go into something else. So I think, again, that's unrecognised…"

- Participant 3

"And there was also the emergence of recycled products [in] the bitumen [used in asphalt]. So car tyres and plastics…all of a sudden [a few years ago waste products like] plastic bottles [were being introduced to the mix]…if it's cooked above temperature, well then what else are you exposing to?"

- Participant 6

"I've got concern about plastics too, and there's a lot more work, as you probably know, being done in this area, especially in Europe. And one of the concerns now is also this plastic recycling, and then you're getting further unknowns in terms of the mixtures of those plastics together.…things like…the plastics that are put into the bitumen, and as cars now sort of drive over it, they release of particle matter…"

- Participant 7

One participant also mentioned the unknown risks related to nanoparticles, as well as lack of good methods to measure exposure currently available.

> "…I know a bit about…nanoparticles and to what extent they're an issue or not is not clear. In some areas they almost certainly are, but it's unclear the extent to which exposure is an issue. It's even difficult to know how to measure exposure appropriately with nanoparticles. So I guess you do need to talk about that if you're thinking about emerging areas"
> - Participant 2

The same participant indicated that PFAS should be on the radar for some professions at risk for large exposures, but also reflected that it's unclear how the wider public conversation about PFAS in the environment shapes the conversation about risk.

> "PFAS is, that's a good thing, controversial thing to talk about, and that raises an issue for me…[It's] an important area, I think, in occupational health and safety, but more broadly in public health and even more broadly probably in life in general, is people losing perspective. And I'm very keen professionally to help people to properly understand risk and to not expect to live in a risk-free world…"
> - Participant 2

Mental health*

Mental health issues were highlighted by nearly all participants. High stress professions were singled out by some participants. Changes in working arrangements (e.g. working from home) and workplace cultures around mental health and acceptable behaviours were also mentioned quite often. Secondary mental health impacts of physical injuries were also mentioned.

> "But **PTSD** I think is a very big problem under recognised, especially in emergency services, police, firefighters, ambulance, I think even vicarious trauma amongst people who, for example, work in child protection and those kinds of industries. I think it's a big under-recognized problem. There's been a recent programme by the relevant union, the CPU, to try and get wider recognition of that. And I think that's a good thing. But just sort of work-related stress and depression. There's a lot of secondary mental health effects from physical compensation claims. And I see a lot of those are panels where there's been a secondary claim that's been accepted because of difficulties in the claims process"
> - Participant 3

> "…what's changed since Covid is a lot more people are working at home…They're probably also trying to juggle kids and domestic work, and I think we may end up with more, actually in some ways, a more stressful work environment because you're trying to juggle things…"
> - Participant 4

> "But adverse mental health, I should say, within the workplace, I find it hard to get a good feel for how big a deal it is and what the main issues are with it. Clearly there's at least a perception that it's a big problem and I think it probably is a big problem. It's not well addressed…Part of it I think are things that probably have always gone on that probably aren't that big a deal, but people now feel a big deal…"
> - Participant 2

"…mental health related claims, I think have [increased]…"
- Participant 1

Dermatological issues*

Some participants mentioned contact dermatitis as an issue that could merit additional focus. One provided a particularly nuanced account of the issues.

> "…contact dermatitis, allergic contact dermatitis. So I think that's a bit of a sleeper"
> - Participant 3

Similar to other sections, linking occupational exposures to illnesses is often a challenge, especially in high turnover professions.

> "They end up leaving work, somebody else comes in to do their job and start the cycle all over again… There are hundreds of these sensitisers out there in industry…The hairdresser is just one of 'em, but there are many, many more. So I think skin disease is really important…"
> - Participant 3

> "I think a lot of these people turn up at their local doctor with clear dermatitis, but the occupational cause is missed for, just don't ask about it basically."
> - Participant 3

Surveillance and monitoring approaches

Data linkage and better utilisation of existing data sets

Opportunities for data linkage was the most frequently discussed theme under this topic.

The opportunities presented by well-structured administrative data sets, that collect data provide means for linkage, like postcodes, were seen to be of great value by several participants.

> "So I have the administrative data on occupational health claims from [organisation]. And because the date and postcode of the affliction, it's not just the claim itself, but the affliction is recorded in the database, I'm able to link the weather conditions onto the date of the accident. So that includes things like the temperature pollution, humidity, precipitation, and then I set up a longitudinal panel sort of thing."
> - Participant 1

The same participant reflected that Australia has comparatively strong data for data linkage projects on a national level.

> "I mean think Australia's in a pretty strong position because the other database, so Safe Work Australia has the national data set for compensation-based statistics and that's a data set that contains standardised data items from all the different jurisdictions and you can get about 20 years worth of occupational health claims from that. So I think in terms of the data, there's kind of a pretty good classification system for each claim."
> - Participant 1

Effective utilisation of other existing databases, whether on their own or for linkage, was also mentioned by a few participants. These approaches can also support the identification of issues that may be missed in industry-specific surveillance programs.

> "…also things like PBS, the pharmaceutical benefits. So that's tricky to try and interpret, but it should be a fairly straightforward thing. And if you link it in with hospital data and various other medical record data, I think now you can get a more complete picture of a person's health, and you can do it at more regular intervals as well. Quite often with direct interviews with people in surveillance programmes is they leave the industry and it's difficult to maintain contact with them."

- Participant 3

"So hospital data, whether it's general practice data as well, although it's often pretty limited, but also compensation data and some of these chronic disease registries as well that have been set up. There are musculoskeletal registries of various sorts, like joint registries, which could be exploited a little more as well…"

- Participant 3

"…[with] the PBS…[you] can look at things like use of meds and…what they're used for. So you might get issued the same pill for cholesterol as you get for, I don't know, high blood pressure. But when it's coded on the PBS, it tells you what it's for… that's useful in terms of then looking at outcomes. So you can see who's been medicated for high blood pressure, who's been medicated for cholesterol, whatever…

- Participant 4

Cohort studies

Several researchers felt that robust, well-designed, well-supported cohort studies could help identify a range of issues.

"… I'd like to see a lot more cohorts established with high risk industries, and how you define [high-risk] is up for debate. But certainly where there are there the possibility of some kind of exposure, which is going to, could cause chronic some sort of illness, whether it's acute or chronic, probably more so with the chronic conditions, you're not going to really pick it up with acute conditions. **But the more semi-acute like asthma, which takes some months to sort of develop and chronic, which is often years. I think having effective cohorts or surveillance programmes set up is really important**…"

- Participant 3

Ethics and access issues

Making useful datasets accessible and ethics processes reasonably navigable was seen as an important enabler of undertaking work to better research related to this subject.

"So accessing the WorkSafe data was more straightforward. I suppose that was kind of because you just accessing…the national level [database], you make a request, but it is not necessarily straightforward because you need to get permission from the different jurisdictions you want to use. So it can take time. So it's like something you can do if you've got a research project, but I wouldn't say it's straightforward"

- Participant 1

"Now that's more complicated because you have to get permission of all of the states and territories for use of their data, and it's become a rather complicated process. I'd like to see a much simpler process, usually three approvals needed for each state and territory."

- Participant 4

"…ethics is a nightmare. Ethical oversight is absolutely key. That's fine. I have [to go to multiple ethics review committees], but then I have to go to all the states and territories…If an ethics committee asks you to change the protocol, they don't seem to understand [the potential implication]. That means you then have to take it back through all the ethics committees that you've already…You could be in an endless circle…Why does it have to go to 11 different ethics committees?"

- Participant 4

Regular health assessments from exposures/industries

Health assessments at regular intervals in high-risk industries and exposure locations were also mentioned as a strategy that should be used more frequently. This approach could possibly be accomplished through regulation in some cases.

> "And a good example…[is] coal mine workers in Queensland. They were doing, they regulated regular health assessment, so they need to be done at periodic intervals …I think we need more of that…to some extent it's not easy, but there are certainly ways of doing it, especially now with remote reading of X-rays with storage capabilities now that we didn't have in the past..."
>
> - Participant 3

Registries

Several participants indicated the value of establishing registries but also indicated that they need to be actively promoted and that participating health professionals should be meaningfully engaged in surveillance processes.

> "We haven't had a national Occupational Respiratory Disease registry before, and it's something we've advocated for a long, long time…[however due to some management issues] many of us doctors have…been disengaged…it would be great…to **promote it** more proactively to physicians to get more reporting of occupational respiratory diseases to it….my fear with it is if we don't use it, [it may be defunded]…"
>
> - Participant 7

AI for screening

The only participant who mentioned using AI was in reference to the possible involvement of AI technology in radiological respiratory disease screening.

> "…with AI and radiology, one of the other big areas in respiratory medicine is the launch of the lung cancer screening programme, which I think is coming online middle of next year..."
>
> - Participant 7

Human intelligence

Multiple participants felt that establishing better systems, processes, and networks to exploit the nuanced knowledge and intuition of health professionals may be a very useful tool in identifying emerging and re-emerging occupational illnesses and diseases.

> "…[a specialist physicians had] a lot of difficulty getting [occupational respiratory diseases onto the agenda when he was seeing these cases coming through…we didn't have a sort of pathway in of advisory. So I think that's a real limitation here to tap into those people at the coalface who are seeing these cases come through."
>
> - Participant 3

There are potentially valuable models to adapt from the UK and Canada.

> "Really variable between countries. So the UK has a model where they have very much supported development of a network of occupational nurses, so occupational health nurses, and they are doing a lot of on the ground interaction with the workplaces and industry. And then I think my understanding is that when they identify an issue, then they'll get the physicians involved. I think that's a very good model. And then I think certainly in Canada, in Canada, there's just a little bit more general awareness of [occupational respiratory illnesses], and I think a bit better referral to appropriate physicians to make a diagnosis. It's much more topical with their regulatory agency than it has been with ours…So I think a bit of it's really that response from the agency and I guess their awareness of it."
>
> - Participant 7

These processes could be further supplemented by general practitioners having greater awareness of the most common occupational illnesses and diseases, and this might support them in being more aware about occupational contributors to illnesses more generally.

> "I think there's a few gaps in the way we identify cases starting from the case. I think awareness of conditions that are common in workspaces would be one of them…I think creating awareness in workspaces of the most common conditions and symptoms, sometimes these conditions have very broad symptoms that could really be anything…"
>
> - Participant 8

Maps

One participant also felt that publicly available location and image data could be used to identify potential exposure sites adjacent to businesses using high-risk materials/substances. In reference to engineered stone, some businesses had open doors from which dust flew.

> "…[some adjacent businesses even] had EPA out to them because the amount of dust was coming out. I do wonder whether there's a way of using Google Street View, whether you can actually use Google Street View to look at workshops…you could imagine that if you know where the industry or where the workplaces are, you have a look at street view, you can actually get a bit of an idea about what it looks like. Obviously it's one single point in time."
>
> - Participant 7

Monitoring with wearables

A few participants indicated that there are new wearable devices for monitoring exposures related to some respiratory illnesses.

> "And in terms of respirators, now we've got some advanced respirators now that people can use and attach to their body where it's not really a bother to them…You can just attach it to your collar like a jewellery and you don't have to worry about it."
>
> - Participant 5

However, some tools are still being validated and may not be recognised as sufficiently accurate for exposure monitoring.

> "…[some workers] got [wearable exposure monitoring devices] sponsored through [a law firm]…[but employers] refuse to even recognise them as a tool to test for exposure."
>
> - Participant 6

Relevant changes in work and workplaces

Many of the interview participants preferred to comment primarily on their areas of expertise, and therefore the findings on this topic were relatively limited.

Working from home

Three interview participants cited that new norms related to working from home. Following the COVID-19 pandemic may also be the source of several occupational illnesses or diseases increasing in the coming years. Issues like musculoskeletal conditions, mental health issues related to stress or feelings of isolation, and conflict between employers and settings due to less frequent interaction amongst teams were all noted.

> "…I have no idea how good the ergonomic setup is for most people at home. I suspect not good…"
>
> - Participant 4

"…I think [working from home is] causing quite a lot of angst amongst the workplace, which could again increase the workplace stress aspect, especially if people feel like they're being forced to [return to the office more than they would like]… I think in terms of psychological health in the workplace, [working from home] could continue to have a big impact…"

- Participant 3

"…I wonder about the long-term cohesiveness of the workforce. And people get a lot of validation from being at work, but that doesn't come so much from the work they're doing as the interaction with the people…"

- Participant 4

AI and automation

One interviewee commented that emerging technologies like, AI, automation, and remote control of devices may reshape workplace safety, but did not comment directly on illness or disease.

"I think an emerging issue is the use of AI in industry and how that will impact on health and safety. A lot of the machinery and a lot of the processes are being automated now, but how does that impact or how does that affect safety…For example, the mining industry here in Western Australia [are] trying to get rid of the train drivers or the dump truck drivers and they…can control a dump truck remotely kilometres away. So what are the safety implication of that [for both the drivers and people working near the truck]? What happened when there's computer errors, when there's failure in technology, how does that impact the safety on site? I think these are some of the pressing issues and how much should we rely on technology to guarantee or ensure safety…"

- Participant 5

Older people remaining in the workforce

The same participant indicated that there are a number of risks related to older workers rejoining the workforce that have not been well considered.

"…there are people that are over 65 now that are going back in the workplace…the question is, these people come or pose or are exposed to different risk at the workplace because of the fragility, because of the state of their physical body, their mental status…"

- Participant 5

Action points

Role of the regulator

Although this does not relate directly to the question, it does provide broader insight into how interview participants felt that WorkSafe and other regulators could best engage around risk mitigation.

A few participants were supportive of the idea that occupational health and safety regulators should play an active role in educating employers and workers about risks and taking a partnership approach.

"I think it's important…[that inspectors] should have an educational role as well as a regulation enforcement role…If they have just an enforcement role, then employers of workplaces will tend to hide things and won't improve, and we'll sort of play the odds and presume they're not going to get inspected because the inspector can't go around to every workplace...."

- Participant 2

Better use of proprietary data

Some participants felt that some industries have cultures that are not sufficiently oriented towards data sharing and appropriate use.

> "… I think a lot of different organisations are conducting different sort of surveillance, but most of the time those data are not used or are not communicated back to workers or to the public in a way to inform people better….It's not properly reported."
>
> - Participant 5

Indeed, more than one participant felt that some employers hide data that show they may be putting workers at risk, and this has serious implications for workers if/when they might be able to make a workers compensation claim.

> "…people getting pushed onto income protection instead of work cover or work cover or care, depending on the coverage, there needs to be huge fines for those companies that are caught to doing that because you can't get the data to support intervention. They're hiding it…"
>
> - Participant 6

Risk mitigation

Product life cycle assessment and understanding

Multiple participants felt that the whole lifecycles of products/substances used by workers should be better understood and considered. For instance, in relation to engineered stone, experts felt that authorities may have considered the potential risks from the likely uses and waste products from this product better. These points are also supported by a quote about recycled products being added to bitumen earlier in this section.

> "Look, it's hard…This slipped through the radar 20 years ago when it was approved for use. There were a lot of papers in the literature that were showing, especially from Israel, that we're showing this is likely to cause a major problem. And those sentinel kind of signals weren't picked up. So I think in terms of new products coming onto the market for use in workplaces, identifying some red flags or having people who might be able to identify those possible red flags and a little closer look at some things…We don't want to sort of hold up approvals, but this way you've got such a high silica content, should have raised some red flags. Maybe a process should have been put in place to look at the literature, look at some early air monitoring data just to get a sense of what sorts of exposures are likely to be seen. And also the workplace context."
>
> - Participant 3

> "So they didn't think about what happens when you start to cut it up. They just looked at the base material and nobody is going to inhale a stone bench, but they are going to inhale the stuff that's predictably formed when you process it…this was an utterly predictable waste material. I mean, we might not have known quite how vicious it was, but we would've known that it was going to have high levels of silica. So I think there's scope for the regulator of who imports stuff to think about predictable waste materials."
>
> - Participant 4

Return to work

One participant also observed that sometimes a staged, smooth return to work, rather than longer periods of leave, may help to avoid secondary occupational illnesses, like mental illness.

> "Recall having a lookout. I think. So it's looking at not just the situation where somebody might have a work related or think they've got a work-related disorder and how it's better that somebody be in work rather than out of work. If you say to me, look, I've got a sore knee and it's because I've been labouring, then it might be useful for you to have a week

off work because you've got an acute inflammatory injury or acute injury that needs to be managed. But…there might be situations where that's appropriate, but in many situations it wouldn't be. And it's better in the long run for you to be at work rather than not to be at work or on adjusted duties…there's been a tension for several decades as to what the connection should be between the workers' compensation system and the occupational health and safety regulator system…"

- Participant 2

Training workers in hygiene

One participant felt that workers in high-risk industries should be encouraged to take short courses in occupational hygiene.

"… threw myself at understanding it all and then I doing one day the five day basic principles of occupational hygiene course. And that was awesome. It really got my head the right questions to be asking…[more workers should be encouraged to do this]"

- Participant 6

SUMMARY OF KEY INTERVIEW FINDINGS

Eight interviews were undertaken with experts with backgrounds in medicine, public health/epidemiology, occupational hygiene, economics, and a range of construction trades. The interviewees had diverse and valuable experiences working in academia, private industry, industry associations, and government and provided a range of insights in relation to the project's overarching research questions.

Emerging and re-emerging occupational illnesses and diseases

The following categories of emerging and re-emerging illnesses and diseases were highlighted by participants (not in order of priority).

Communicable/Infectious diseases

- Several participants mentioned that there were a range of communicable diseases of relevance to this research.
- They highlighted that we should not lose focus on a range of respiratory illnesses, while also paying closer attention to emerging zoonotic infections.

Respiratory illnesses and diseases

- Silicosis, pneumoconiosis, occupational asthma, and lung cancer were frequently mentioned by both participants who have specialist knowledge of respiratory health and non-specialists alike.

Illnesses and diseases related to chemical/nanoparticle exposures

- Hairdressers and similar high-turnover professions with high levels of chemical exposure were mentioned as a key cohort for surveillance.
- One participant expressed concern about our currently lack of knowledge about the risks of some nanoparticles.
- Another mentioned that moving towards a circular economy may expose workers to previously unknown chemical exposure risks through re-processing of materials.

Dermatological issues

- Contact dermatitis was mentioned by several participants.
- One participant noted that dermatological conditions may often not be linked to working conditions by their general practitioners.

Mental health conditions

- Mental health conditions were mentioned by nearly all participants. They mentioned that workers in professions perceived to be high stress, as well as those in other professions, were at risk.
- Participants felt that changes in workplace arrangements following the COVID-19 pandemic and changes in workplace norms about acceptable behaviours likely are contributing to this.

Surveillance and monitoring

The surveillance and monitoring approaches to better identify emerging and re-emerging illnesses and diseases highlighted by participants were as follows.

Data linkage and better utilisation of existing data sets

- Several participants felt that there are growing opportunities to link data sets, for instance by connecting data about workplace illness and climate.
- Several participants also felt that better use existing data sets was merited, noting that we could better capitalise on the nuance present in large administrative datasets (e.g. the PBS).
- They also highlighted several ethics and access issues related to compiling large data sets containing sensitive data

Cohort studies and registries

- Several participants underlined the value of well-supported cohort studies and registries, but that the value of these tools can usually only be realised with sufficient resourcing.

Health assessment in key exposure settings/industries

- Health assessments at regular intervals in high-risk industries and exposure locations were also mentioned as a strategy that should be used more frequently. This approach could possibly be accomplished through regulation in some cases.

Human intelligence

- Multiple participants felt that networks of knowledgeable health practitioners and workers could be better developed and utilised to know what is going on "on the ground"

Artificial intelligence techniques

- Artificial intelligence was mentioned less frequently than anticipated, and when it was mentioned, it was usually mentioned as a validated tool to support diagnostics in some fields.

New monitoring devices, including wearables

- Multiple participants mentioned exposure monitoring devices or bio-monitoring devices, but indicated that many are only mature enough to be used as supplements to more validated tools.

Changes to workplaces and the workforce

A few changes to workplaces and workforce dynamics were mentioned by participants.

- Working from home has reshaped people's risks for musculoskeletal diseases, mental health conditions, cohesiveness of the workforce, and work-home conflict.
- AI and automation raise a number of workplace-specific risks, for instance the impacts of automated or remote control of some machinery in mining. One participant indicated that some of risks related to these concerns have not been fully assessed for workers directly and indirectly affected.
- Older people remaining in the workforce past traditional retirement age may mean safety in some roles may need to newly consider risks related to the cognitive, psychological, or physical profiles of these workers.

Key risk mitigation strategies

Product life cycle assessment and understanding

- Multiple participants felt that better understanding of the whole lifecycles of products/substances used by workers should be better understood and considered.
- These comments were often framed in relation to learning from engineered stone.
- A range of issues pertaining to the emerging circular economy, for instance the implications for re-using a number of types of plastics are not well understood.

Considering how return to work can be included in holistic health considerations

- One participant mentioned that for some injured workers, a staged return to work may help to prevent secondary injuries, like mental health injuries.

Training workers in occupational hygiene

- One participant made a strong argument for more workers to be trained in occupational hygiene to better identify emerging illnesses and diseases, as well as better protect their personal right to a safe and healthy workplace.

OCCUPATIONAL ILLNESS AND DISEASE PROFILES

BACKGROUND

Based on the Request for Service (RFS), Monash University proposed developing a series of short literature profiles that would provide WorkSafe Victoria with a snapshot of some recent, potentially useful peer-reviewed literature on emerging and re-emerging diseases and illnesses. These profiles are a short summary of subjectively selected literature on a topic and are not equivalent to a more rigorous review.

The topics of the profiles were selected by WorkSafe Victoria in consultation with the Monash University team.

METHODS

The development of the profiles involved five distinct steps:

1. Literature scan and selection of subjectively relevant documents
2. In-depth review of included documents (and often a few other documents)
3. Drafting of the profile
4. Backstopping of the profile by a team member who did not write the profile
5. Backstopping of the profile by content-matter expert members of the Monash University team from the Healthy Working Lives Group

Literature search

The literature scan began with an orienting search using Elicit, an AI research tool that uses semantic search technologies to help locate relevant papers even when they don't exactly match the keywords. Results were sorted by relevance and recency to ensure the inclusion of the most recent and pertinent studies. High-quality sources, such as systematic reviews and randomised controlled trials, were prioritised, and articles that the reviewer deemed as relevant were systematically organised using reference management software to streamline the review process.

Following this, the process then involved a search of Scopus and Google Scholar databases. Search queries were designed using key terms and synonyms relevant to the research question, with Boolean operators applied to refine results where applicable. Filters based on publication year and document type were also applied for further refinement of search results.

Finally, citation tracking was also conducted using Google Scholar and ResearchRabbit where titles of relevant papers were explored through citation tracking tools to identify additional sources. Google Scholar's 'Cited by' and ResearchRabbit's 'EXPLORE PAPERS' functions facilitated this process.

Candidate papers were compiled in a Zotero library.

Article selection and synthesis

Upon completing the search, the reviewer subjectively selected 5-15 documents based on the volume and quality of information responding to the research questions on the topic. Reviewers also subjectively assessed methodology quality. Information responding to the research questions and topic prompt from selected studies were then extracted and organised into a structured profile, which included key findings and a list of key insights that distilled the main findings. Note: due to the nature of profile topics, existing evidence base, and nature of the search and selection process, some profiles address some research questions more than others.

Upon completion of a profile, a reviewer who did not work on the profile crosschecked and validated included studies and the data extracted from them, proofread and copyedited the profile and, confirmed that the key insights were an effective distillation of the detailed summary. Finally, content experts from Monash University's Healthy Working Lives Group backstopped each profile to further ensure the accuracy, validity, and robustness of the findings.

Limitations

Not all potentially includable documents were included in the profiles, and those that were included were subjectively selected. The scope of the project limited the research team's ability to include all relevant documents. The scope limitations required that the research team included no more than 5-15 documents per profile and made it so that only a subjective selection of documents was possible. This means that the included documents do not comprise all relevant documents that result from the search strategy, and moreover, the included documents may reflect the biases of the team member who selected them. To mitigate the impact of these limitations, highly relevant review-level evidence was given preference because, in many cases, they provide an accurate representation of the state of a whole field of evidence and have sought to mitigate these concerns related to biased document inclusion. Moreover, the backstopping process was used to maintain quality as well as identify "blind spots" in the profile. However, it should be reiterated that the profiles do not represent a comprehensive search, nor systematic selection, which would be used in a rapid or systematic review.

PROFILE 1: CHEMICAL EXPOSURE AND MISCARRIAGES IN HEALTHCARE WORKERS

Key Insights

- Endocrine-disrupting chemicals (EDCs) like pesticides, BPA, and phthalates in healthcare settings contribute to reproductive issues such as endometriosis, ovarian failure, and infertility among healthcare workers.
- Dental professionals exposed to mercury, disinfectants, anaesthetic gases, and acrylate compounds face increased risk of miscarriage and other reproductive health issues.
- Healthcare workers exposed to ionising radiation, anaesthetic gases, chemotherapy drugs and other hazardous chemicals face a heightened risk of adverse pregnancy outcomes.
- Female surgeons have more than double the pregnancy loss rate compared to the general population.
- Frequent risk assessments, proper training, workload management, and biomarker monitoring are critical to ensuring workplace safety and reducing chemical exposure risks for healthcare workers.

Overview of the issue

Beginning in the 1970s, several epidemiological studies have examined the risks healthcare workers face regarding reproductive issues like foetal death, birth defects, and infertility due to exposure to workplace hazards (Warembourg et al., 2017). The medical industry heavily relies on polycarbonate plastics made with Bisphenol A (BPA) for items such as food storage containers, water bottles, cans, and bottle caps (Hassan et al., 2024). BPA is a synthetic chemical from the phenol group that has been used since the 1960s, particularly in plastic and resin manufacturing. Warembourg et al. (2017) conducted an updated systematic review of research from 2000-2015 focusing on healthcare workers' exposure to occupational hazards, linking exposure to miscarriage, congenital disabilities, and fertility problems.

Endocrine-disrupting chemicals (EDCs) have also been shown to negatively affect women's reproductive health, contributing to issues like endometriosis, ovarian failure, menstrual irregularities, and infertility (Hassan et al., 2024). In healthcare settings, workers are at risk from several hazards in hospitals, such as radiation, anaesthetic gases, and strong disinfectants, in addition to physical and ergonomic dangers (Taskingul et al., 2024). For instance, healthcare workers, including dentists and dental assistants, are exposed to various hazardous chemicals like mercury, disinfectants, anaesthetic gases, as well as x-rays, all of which pose reproductive health risks (Lindbohm et al., 2007). Workers handling chemotherapy drugs, particularly antineoplastic agents, face further risks, as these substances can contaminate healthcare environments, be absorbed by workers, and increase biomarkers of genetic damage, leading to reproductive issues, skin disorders, and cancer (Connor et al., 2015).

A recent multidisciplinary review by Pahnabi et al. (2024) highlighted that healthcare workers exposed to radiation, anaesthetic gases, and other chemicals are at risk of fertility issues. According to this review, a study by Rangel et al. (2018) involving 692 female and 158 male surgeons found that 42% of the female surgeons reported pregnancy loss, which is more than double the rate in the general population. The review also noted that women working in environments with exposure to anaesthetic gases face a significantly higher risk of miscarriage (Pahnabi et al., 2024). Additionally, extended exposure to high levels of ionising radiation is associated with fertility problems and an increased risk of pregnancy complications, including congenital malformations (Pahnabi et al., 2024).

Recent research and trends

Healthcare professionals should be aware of the potential risks associated with exposure to endocrine-disrupting chemicals (EDCs) and consider environmental factors when assessing patients (Hassan et al., 2024). Occupational hazards like chemotherapy drugs, anaesthetic gases, sterilisation agents, and chemicals such as xylene and formaldehyde have been linked to various health problems, including liver and skin diseases, respiratory issues, and varicose veins (Taskingul et al., 2024). Exposure to chemotherapy drugs, in particular, has been linked to a heightened risk of miscarriage and congenital malformations (Connor et al., 2015). Similarly, exposure to certain sterilising agents, antineoplastic drugs, and ionising radiation is linked to a higher likelihood of miscarriage, though evidence does not suggest an increased risk of stillbirth (Warembourg et al., 2017).

Studies have shown that healthcare workers have a higher risk of congenital anomalies, especially affecting the nervous and musculoskeletal systems, but have not found evidence of an increased risk of foetal death (Warembourg et al., 2017). Reports have also shown that 40.4% of health technicians regularly encounter anaesthetic gases and ionising radiation, 38.3% are exposed to surgical smoke, and around 17% of midwives and health technicians are exposed to formaldehyde (Taskingul et al., 2024). Recent studies highlight that phthalates (chemicals used to increase the durability of plastics) can damage ovaries, potentially causing infertility or early ovarian failure in women (Hassan et al., 2024).

In dental settings, research into how acrylate compounds affect reproductive health is both limited and shows mixed results, indicating a need for further investigation (Lindbohm et al., 2007). Over the past decade, the decline in amalgam use and the rise of methacrylic-based composites resulted in increased exposure of healthcare and dental lab workers to acrylate compounds, metal dust, and fumes (Lindbohm et al., 2007). Lindbohm et al. (2007) further explained that women who used protective equipment while grinding acrylate products or worked in the same room for less than seven hours per week were still classified as exposed to organic PMMA dust. Moreover, it was reported that dental procedures such as placing or removing fillings, and polishing or finishing dental work exposes workers to mercury as well (Lindbohm et al., 2007). Women (Lindbohm et al., 2007).

Re-emergence of known disease issues

A large number of people are frequently exposed to endocrine disruptors, but the effects of these exposures often only become evident later in life. In some cases, these effects can even persist across multiple generations (Hassan et al., 2024). Recent research has highlighted an increased risk of miscarriage linked to ethylene oxide exposure, while solvents commonly found in sterilising agents and disinfectants have been strongly associated with a higher risk of foetal death (Warembourg et al., 2017). Marsters et al. (2023) assessed current research on how occupational hazards faced by physicians affect pregnancy and neonatal outcomes, finding that occupational risks faced by pregnant physicians are inconsistent, with many studies being biased, relying on outdated data (Marsters et al., 2023). The implementation of Class II biological safety cabinets in the 1980s helped reduce healthcare workers' exposure to antineoplastic drugs, but the protection was not as effective as initially expected (Connor et al., 2015).

Although many studies focus on the reproductive risks associated with antineoplastic drug exposure among healthcare workers, their findings may also apply to those exposed to other hazardous drugs (Connor et al., 2015). Research into maternal exposure to antineoplastic drugs during the first trimester has shown a higher rate of miscarriages in women handling these substances (Connor et al., 2015). Persistent organic pollutants (POPs) found in contaminated foods like meat, fish, and dairy products can cause a range of adverse health effects, including issues with growth, development, and the reproductive, neurological, endocrine, and immune systems (Hassan et al., 2024). A slightly increased risk of miscarriage was identified for healthcare workers exposed to organic solvents and disinfectants (Lindbohm et al., 2007). There is also an elevated risk of certain congenital anomalies reported among healthcare workers, especially those exposed to anaesthetic gases, compared to the general population (Warembourg et al., 2017).

Monitoring and surveillance

In a 2007 study, Lindbohm et al. investigated female dental workers' exposure to dental restorative materials, comparing them with a control group of non-exposed workers. Pregnancy data was collected from national registers and hospital outpatient records, while an occupational hygienist measured exposure to acrylate compounds such as HEMA, MMA, PMMA dust, disinfectants, and solvents (Lindbohm et al., 2007). The study found no strong association between occupational exposure to chemical agents or restorative materials and miscarriage risk among dental personnel. However, due to a small, non-significant increase in risk observed for some acrylate compounds, mercury amalgam, solvents, and disinfectants it could not be ruled out that there was a slight increase in the risk of miscarriage among exposed dental workers (Lindbohm et al., 2007).

Biomarker monitoring, frequent risk assessments, and proper training are essential components of hospital safety programmes to minimise chemical exposure risks (Taskingul et al., 2024). Despite their importance, only a few studies have used direct workplace exposure measurements or expert assessments, though these are now the standard methods (Warembourg et al., 2017). In areas where antineoplastic drugs are prepared or administered, surface contamination measurement is currently considered the most effective technique for assessing environmental contamination (Connor et al., 2015). Due to the potential for low-level exposure to drugs with harmful reproductive effects, it is crucial to increase vigilance and protective measures for healthcare workers at high risk of reproductive and developmental harm (Connor et al., 2015).

Risk control and mitigation measures

As healthcare workers may be exposed to low levels of drugs with reproductive risks, increased vigilance and protections are necessary for those most susceptible to reproductive and developmental effects (Connor et al., 2015). It is essential for dental workers to follow proper occupational hygiene practices, especially during pregnancy (Lindbohm et al., 2007). Although recommendations have been made to limit healthcare workers' exposure to hazardous substances, there are still reports of adverse pregnancy outcomes, which require further investigation (Warembourg et al., 2017). Certain infections can pose risks during pregnancy, making it vital to adhere strictly to infection control measures. This includes following safety protocols, ensuring adequate ventilation, and using personal protective equipment in healthcare settings to reduce these risks (Pahnabi et al., 2024).

Recent efforts to reduce workplace contamination have included the use of engineering controls such as compounding aseptic containment isolators (CACIs), robotic systems, and closed system drug transfer devices (CSTDs). However, research indicates that despite these measures, complete elimination of exposure to antineoplastic drugs in healthcare settings is still not possible (Connor et al., 2015). Although guidelines have been implemented to reduce exposure among nurses, a recent study highlights that these guidelines are not always adhered to (Warembourg et al., 2017).

Conclusion and future directions

Addressing the effects of endocrine-disrupting chemicals (EDCs) and reducing chemical exposure requires immediate action (Hassan et al., 2024). A slight but non-significant increase in miscarriage risk was observed among dental workers exposed to acrylate compounds, mercury amalgam, solvents, and disinfectants, but due to simultaneous exposure to various materials, the risk cannot be attributed to a single source (Lindbohm et al., 2007). There is a need to improve the precision of studies on healthcare workers, particularly in evaluating working conditions over specific time periods, and establish clear guidelines to support pregnant physicians (Warembourg et al., 2017; Marsters et al., 2023).

Marsters et al. (2023) suggests that longer work hours and increased night shifts may raise the risk of miscarriage and preterm birth. Pregnancy policies in medical organisations should consider limiting work hours and night shifts, especially in early pregnancy and for those with other risk factors like multiple pregnancies or previous preterm labour (Marsters et al., 2023). Pregnant physicians should receive institutional support to attend prenatal appointments, and workplace accommodations should be made based on their obstetric provider's judgement (Marsters et al., 2023). Offering accommodations to pregnant and nursing workers is not only supportive but also makes good business sense, as 68% of working women are expected to become pregnant at least once in their careers, with over half of births attributed to working women (Connor et al., 2015). Healthcare facilities typically have protocols to monitor and reduce occupational exposure to hazards, and operating room staff should be proactive in participating in these safety measures to ensure a secure working environment (Pahnabi et al., 2024).

Regular risk assessments, comprehensive training, workload management, and biomarker monitoring are essential components of ensuring workplace safety in hospitals (Taskingul et al., 2024). Well-designed studies are necessary to investigate the risks faced by female physicians, which is increasingly feasible given the growing number of women entering the medical field (Marsters et al., 2023). Due to the mechanisms by which hazardous antineoplastic drugs affect the body, evidence to date indicates an increased risk to reproductive health among exposed workers (Connor et al., 2015). Other research highlights the importance of tailored workplace interventions, which should include ergonomic adjustments, mental health support, and stringent infection control protocols (Pahnabi et al., 2024).

Given the harmful effects on fertility and overall health, exposure to certain endocrine-disrupting chemicals (EDCs), such as pesticides, BPA, and phthalates, should be minimised for couples trying to conceive (Hassan et al., 2024). Warembourg et al. (2017) illustrated ongoing risks of adverse reproductive outcomes, suggesting that better control of working conditions and possibly a re-evaluation of exposure limits are needed. Collaboration between healthcare professionals, policymakers, and reproductive health experts is crucial for creating strategies that address the socio-cultural and systemic factors influencing reproductive health (Pahnabi et al., 2024).

When it comes to antineoplastic and other hazardous drugs, there is a need for clear guidelines to protect healthcare workers ensuring their reproductive health and safeguarding their offspring's well-being (Connor et al., 2015). Future research should aim to enhance knowledge of specific occupational risks, establish clearer causal links, and advocate for workplace policies that prioritise the reproductive health and safety of operating room staff (Pahnabi et al., 2024).

References

Connor, T. H., Lawson, C. C., Polovich, M., & McDiarmid, M. A. (2015). Reproductive health risks associated with occupational exposures to antineoplastic drugs in health care settings: A review of the evidence. *Journal of Occupational and Environmental Medicine, 56*(9), 901–910. https://doi.org/10.1097/JOM.0000000000000249

Hassan, S., Thacharodi, A., Priya, A., Meenatchi, R., Hegde, T. A., Thangamani, R., Nguyen, H. T., & Pugazhendhi, A. (2024). Endocrine disruptors: Unravelling the link between chemical exposure and women's reproductive health. *Environmental Research, 241*, 117385. https://doi.org/10.1016/j.envres.2023.117385

Lindbohm, M.-L., Ylöstalo, P., Sallmén, M., Henriks-Eckerman, M.-L., Nurminen, T., Forss, H., & Taskinen, H. (2007). Occupational exposure in dentistry and miscarriage. *Occupational and Environmental Medicine, 64*(2), 127–133. https://doi.org/10.1136/oem.2005.026039

Marsters, C. M., Stafl, L., Bugden, S., Gustainis, R., Nkunu, V., Reimer, R., Fletcher, S., Smith, S., Bruton Joe, M., Hyde, C., Dance, E., & Ruzycki, S. M. (2023). Pregnancy, obstetrical and neonatal outcomes in women exposed to physician-related occupational hazards: A scoping review. *BMJ Open, 13*(e064483). https://doi.org/10.1136/bmjopen-2022-064483

Pahnabi, A., Kameli, F., Rahimi, M., Abdollahi, A., & Daneshian, M. (2024). Exploring the spectrum of pregnancy complications amongst operating room personnel: A multidisciplinary review. *Journal of Women Health Care and Gynecology, 3*(3), 1–14.

Rangel, E. L., Smink, D. S., Castillo-Angeles, M., Kwakye, G., Changala, M., Haider, A. H., & Doherty, G. M. (2018). Pregnancy and Motherhood During Surgical Training. *JAMA Surgery*, *153*(7), 644–652. https://doi.org/10.1001/jamasurg.2018.0153

Taskingul, A. B., Kiran, S., & Emerce, E. (2024). Comparison of health complaints, occupational risks, and occupational health practices of healthcare workers according to professions and departments in the hospital. *Cureus, 16*(7), e65614. https://doi.org/10.7759/cureus.65614

Warembourg, C., Cordier, S., & Garlantézec, R. (2017). An updated systematic review of fetal death, congenital anomalies, and fertility disorders among healthcare workers. *American Journal of Industrial Medicine, 60*(6), 578–590. https://doi.org/10.1002/ajim.22711

PROFILE 2: MOSQUITO-BORNE ENCEPHALITIS (WITH A FOCUS ON THE IMPACT OF CLIMATE CHANGE)

Key Insights

- Encephalitis is an inflammation of the brain caused by various pathogens, such as viruses, bacteria, and parasites. Mosquito-borne encephalitis is a global health issue, with over 700,000 annual deaths linked to these illnesses.
- Climate change is influencing zoonotic infectious diseases, including encephalitis, by altering the environment for disease carriers like mosquitoes, impacting the timing and spread of outbreaks.
- Emerging diseases like Japanese encephalitis (JE) and Murray Valley encephalitis virus (MVEV), are increasingly being found in new areas due to climate and land use changes.
- In Australia, encephalitis outbreaks, particularly of JE, have been linked to climate change, and regions like rural Victoria now face greater infection risks.
- Current diagnostic tools for encephalitis are limited, with surveillance in Australia only documenting laboratory-confirmed cases, leaving gaps in tracking to prevent outbreaks.
- New technologies, such as geospatial analysis using graphical information systems, remote sensing, and machine learning, are helping predict the spread of diseases like JE, with climate and public health data integration improving disease monitoring and early detection.
- The severity of Murray Valley encephalitis outbreaks underscores the importance of integrated surveillance and public health measures to mitigate future outbreaks.

Overview of the issue

Climate change is influencing zoonotic infectious diseases by creating new environments for disease carriers and altering the timing and location of outbreaks (Fayisa, 2023). Mosquito-borne illnesses, including encephalitis, represent a major global health issue, responsible for over 700,000 deaths annually (E Silva et al., 2024).

Encephalitis, an inflammation of the brain, is often suspected when a patient has fever, headache, and signs of widespread brain dysfunction, sometimes with specific neurological symptoms (Huppatz et al., 2009). Japanese encephalitis (JE) is a rare but serious brain infection spread to humans by mosquitoes carrying the virus. It is predominant in parts of Asia and the Western Pacific (Department of Health, 2024; Gossner et al., 2023). Murray Valley encephalitis virus (MVEV) (commonly found in northern Australia) is an uncommon yet serious illness also transmitted to humans through mosquito bites (Better Health Channel, 2023). MVEV is notable for long periods of inactivity punctuated by substantial outbreaks, causing significant mortality. Historical outbreaks in south-east Australia include those in 1974 and 2011 (Braddick et al., 2023). In high-income countries, herpes viruses are the most common cause of acute encephalitis, but the exact pathogen is not always identified (Huppatz et al., 2009).

Impact of climate change

Outbreaks of encephalitis are increasingly tied to climate change, land use alterations, and shifts in human behaviour (Venkatesan, 2021). Global warming creates conditions that help disease vectors, such as mosquitoes and ticks, spread and thrive. Changes in climate, like heavy rainfall and increased warmth, help mosquitoes flourish and influence bird migration patterns, both of which can spread diseases (Gossner et al., 2023).

Climate change is impacting mosquito populations by altering their survival, reproduction, and transmission patterns, which shifts the incidence and spread of zoonotic diseases like JE and MVEV.

Transmitted through bites from infected Culex mosquitoes, JE is directly influenced by these climate-driven changes to disease carriers and their habitats (E Silva et al., 2024; Fayisa, 2023). For instance, an increase in precipitation in early 2022 contributed to higher risk areas for JE emergence in the state of Victoria (Flores Lima et al., 2024).

The risk of MVEV outbreaks is assessed through climate models like Forbes', Nicholls, and Bennett hypotheses, which examine factors such as rainfall patterns, mean sea level pressure, and the Indian Ocean Dipole (Braddick et al., 2023). The 2022–2023 MVEV outbreak aligned with predictions due to La Niña weather patterns and flooding (Braddick et al., 2023). Predictions suggest that mosquito populations, which were previously confined to tropical and subtropical regions, will expand into temperate climates (E Silva et al., 2024).

Current trends in the field

Epidemiological Data

Re-emerging diseases are those that reappear after a decline signalling a breakdown in public health systems (Fayisa, 2023). Although encephalitis is rare, it remains a significant public health concern due to its severity and the potential for severe complications (Huppatz et al., 2009). For instance, six human cases of MVEV were confirmed in Victoria during the MVEV outbreak of 2022-2023, with a high case fatality rate of 83%, highlighting the severity of the disease (Braddick et al., 2023). A prompt response is critical not only for patient outcomes but also for preventing further transmission (Huppatz et al., 2009).

Recent statistics indicate changes in incidence rates in the last 20 years. About one-third of emerging infectious diseases have been transmitted by vectors, especially mosquitoes (E Silva et al., 2024). In recent years, several viral infections spread by mosquitoes and ticks have caused encephalitis outbreaks (Venkatesan, 2021). Waterbirds such as egrets and herons can carry and spread JE across long distances without showing symptoms (Gossner et al., 2023).

There are geographic regions experiencing cases of encephalitis related to diseases that are not currently present in Australia, like the Nipah Virus (NiV). In a recent study conducted by Suman et al. (2024), Bangladesh and Malaysia had the highest number of NiV cases, with a 61% case fatality rate, and risk factors including exposure to pigs, nighttime bats, tree climbing, and being male. Fruit bats spread NiV by contaminating local plants and fruit trees with their saliva, urine, and faeces (Suman et al., 2024).

Connection to work

In Australia, several new and re-emerging pathogens related to encephalitis have appeared, including in new geographic areas (Huppatz et al., 2009). In 2022, JE was detected for the first time in humans, pigs, and mosquitoes in southern regions of Australia, further south than previous cases (Department of Health, 2024). Therefore individuals who live, work, or spend time outdoors in rural Victoria, particularly near the Murray River, now face a greater risk of infection (Better Health Channel, 2023).

Monitoring and surveillance

Surveillance is crucial for detecting emerging public health threats, as novel infections are often tied to human activities like population density and climate change (Christaki, 2015). Blood and cerebrospinal fluid tests are commonly used to diagnose encephalitis (Suman et al., 2024). In New South Wales (NSW), nearly 70% of encephalitis cases had no known cause, highlighting gaps in current diagnostic tools (Huppatz et al., 2009).

Early detection of JE in both human and animal cases is vital to controlling outbreaks, as person-to-person transmission can sometimes occur (Gossner et al., 2023; Venkatesan, 2021). Innovative methods like geospatial analysis can help predict the spread of diseases like JE. For instance, using geographic information systems (GIS) and climate models, researchers have identified areas in Victoria at risk of JE emergence (Flores Lima et al., 2024). This model accurately predicted cases in seven out of eight regions affected by the 2022 JE outbreak in piggeries (Flores Lima et al., 2024).

Tools like event-based systems, social media analysis, and search engine queries can be valuable for early detection (Christaki, 2015). Expanded vector surveillance systems, such as those in Victoria during 2022–2023 have effectively detected MVEV in mosquitoes in advance of human cases, serving as an early warning system. Equine monitoring played a role in outbreak detection, with horses across 35 LGAs tested for flaviviruses. Only one probable case was detected, suggesting limitations in testing or differences in host susceptibility (Braddick et al., 2023). Surveillance of emerging diseases also relies on technologies like remote sensing and satellite imaging to predict disease trends (Christaki, 2015). Combining public health data with climate data and using machine learning to identify patterns could improve monitoring efforts (E Silva et al., 2024).

Conclusion

Global surveillance systems are essential for limiting future encephalitis outbreaks (Venkatesan, 2021). As global climate change alters average weather and increases extreme weather events, the risks related to encephalitis will continue to evolve. The recent MVEV outbreak underscores the importance of preparedness for vector-borne diseases. Strategies such as climate-informed surveillance, integrated vector control, and rapid public health response are crucial for mitigating the impact of outbreaks (Braddick et al., 2023).

References

Better Health Channel. (2023, March 10). *Murray Valley encephalitis*. Department of Health, Victorian Government. https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/murray-valley-encephalitis

Braddick, M., O'Brien, H. M., Lim, C. K., Feldman, R., Bunter, C., Neville, P., Bailie, C. R., Butel-Simoes, G., Jung, M. H., Yuen, A., Hughes, N., & Friedman, N. D. (2023). *An integrated public health response to an outbreak of Murray Valley encephalitis virus infection during the 2022–2023 mosquito season in Victoria*. *Frontiers in Public Health, 11*. https://doi.org/10.3389/fpubh.2023.1256149

Christaki, E. (2015). New technologies in predicting, preventing and controlling emerging infectious diseases. *Virulence, 6*(6), 558-565. https://doi.org/10.1080/21505594.2015.1040975

Department of Health. (2024, April 24). *Japanese encephalitis*. Victorian Government. https://www.health.vic.gov.au/infectious-diseases/japanese-encephalitis#notification-requirement-for-japanese-encephalitis

Huppatz, C., Durrheim, D. N., Levi, C., Dalton, C., Williams, D., Clements, M. S., & Kelly, P. M. (2009). Etiology of encephalitis in Australia, 1990–2007. *Emerging Infectious Diseases, 15*(9), 1359-1365. https://doi.org/10.3201/eid1509.081540

Fayisa, W. O. (2023). A critical review on the role of climate change in the emergence and re-emergence of zoonosis. *Journal of Life Sciences Research and Reviews, 1*(3), 1-3. https://doi.org/10.47363/JLSRR/2023(1)107

Flores Lima, M., Cotton, J., Marais, M., & Faggian, R. (2024). Modelling the risk of Japanese encephalitis virus in Victoria, Australia, using an expert-systems approach. *BMC Infectious Diseases, 24*(60), 1-17. https://doi.org/10.1186/s12879-023-08741-8

Gossner, C. M., Dhollander, S., Presser, L. D., Briet, O., Bakonyi, T., Schaffner, F., & Figuerola, J. (2023). Potential for emergence of Japanese encephalitis in the European Union. *Zoonoses and Public Health, 71*(3), 274–280. https://doi.org/10.1111/zph.13103

E Silva, R. R., Millett, C., Dittrich, S., & Donato, H. (2024). The impacts of climate change on the emergence and reemergence of mosquito-borne diseases in temperate zones: An umbrella review protocol. *Acta Medica Portuguesa, In Press*. https://doi.org/10.20344/amp.21355

Suman, N., Khandelwal, E., Chiluvuri, P., Rami, D. S., Chansoria, S., Jerry, A., & Tiwari, R. (2024). Nipah virus encephalitis: Unveiling the epidemiology, risk factors, and clinical outcomes – A systematic review and meta-analysis. *Journal of Pharmacy and Bioallied Sciences, 16*(S1), S102–S105. https://doi.org/10.4103/jpbs.jpbs_935_23

Venkatesan, A. (2021). Emerging infectious encephalitides. *Current Opinion in Neurology, 34*(3), 410–416. https://doi.org/10.1097/WCO.0000000000000936

PROFILE 3: MALARIA (WITH A FOCUS ON THE IMPACT OF CLIMATE CHANGE)

Key Insights

- Malaria is a mosquito-borne disease, caused by Plasmodium parasites, and transmitted by mosquitoes of the Anopheles species.
- Although malaria remains a global public health concern with over 200 million cases per year, there has been a reduction in the morbidity of malaria over the past decade.
- In Australia, trends in malaria fluctuate due to its geographic location, traveller demographics, destination choices, and migrant source countries. Most reported cases are imported, primarily from Sub-Saharan Africa, Oceania, and Southern and Central Asia.
- Studies suggested that vector-borne diseases including malaria are most commonly reported among outdoor workers and frequent travellers such as soldiers, migrant workers, miners, farmers, and forest workers.
- Australia would benefit from a surveillance system for workers who frequently travel to endemic areas, especially to prevent imported cases.
- Across the globe, innovations for malaria surveillance strategies and vector control have been developed using technologies such as web-based platforms, mobile applications, and drone technology.

Overview of the issue

Malaria is a mosquito-borne parasite infection that is spread by female Anopheles mosquitoes (Buck & Finnigan, 2024). Malaria is caused by Plasmodium species parasites, including P. falciparum, P. vivax, P. knowlesi, P. ovale, and P. malariae (Buck & Finnigan, 2024). However, plasmodium can also be transmitted through blood transfusion and infected needles, although the risk is low (Buck & Finnigan, 2024). Early infection of malaria generates symptoms such as headache, fever, and chills with an incubation period of 10-15 days (Buck & Finnigan, 2024). When left untreated, malaria can be life-threatening, with complications such as anaemia, nephrotic syndrome and cerebral malaria (Buck & Finnigan, 2024). However, malaria fatality can be significantly prevented with timely detection, diagnosis, and interventions (Buck & Finnigan, 2024).

Recent global trends in malaria show a significant reduction in morbidity over the past decade, with case incidence rates declining in some regions (Dabaro et al., 2020). Moreover, an estimated 2 billion cases and 11.7 million deaths were averted between 2000 and 2021 (Bright Amoah Darko et al., 2023). However, malaria remains a major global health concern, particularly in tropical and subtropical countries, with over 200 million cases annually (Pernicová & Krsek, 2022). Sub-Saharan Africa remains the most affected region, with Western Sub-Saharan Africa experiencing an increase in deaths from 1990 to 2019 (Shi et al., 2023). Meanwhile, in Australia, malaria trends have shown fluctuations over the past decade. Between 2012 and 2022, 3,204 cases were reported, with incidence rates initially declining from 2012 to 2015, then increasing until 2019 (Sohail et al., 2024). These trends are attributed to Australia’s geographic location, traveller demographics, destination choices, and the countries from which migrants originate. The majority of cases were imported, primarily from Sub-Saharan Africa, Oceania, and Southern and Central Asia (Sohail et al., 2024). These findings highlight the ongoing importance of malaria surveillance and control measures in Australia.

In relation to occupations, a systematic review conducted by Msellemu et al. (2024) found that vector-borne diseases such as malaria, leishmaniasis, and dengue are most commonly reported among soldiers (38%), migrant workers (12.5%), miners (9%), and farmers (5%).

Moreover, a qualitative study in Aceh, Indonesia, also discovered that forest workers, including miners and loggers, who spend weeks to months at work sites, rarely utilise mosquito prevention strategies (Ekawati et al., 2020; Gallalee et al., 2024). This highlighted the importance of mosquito prevention strategies in outdoor occupations where the personnel are more likely to be exposed to malaria, especially in endemic areas.

Monitoring and surveillance

In the context of Australia, although local infection is rare, surveillance should be directed towards workers who frequently travel to subtropical countries such as Sub-Saharan Africa, Oceania, Central and South America, as well as Southeast Asia (Sohail et al., 2024). Xu et al. (2021), describes China's implementation of several intensive interventions within a 2.5 km-wide perimeter along the border. The interventions include proactive and passive case detection, intensive vector surveillance, evidence-based vector control, and evidence-based preventative treatment with anti-malarial drugs (Xu et al., 2021). This can be implemented to survey and monitor workers who are returning from malaria-endemic areas. Moreover, chemoprophylaxis can also be recommended to travelling workers (DeVos & Dunn, 2024).

Recent global innovations in malaria surveillance have focused on leveraging technology to improve data collection, integration, and analysis. Web-based platforms, mobile applications, and diagnostic tools have been developed to enhance malaria response efforts (Chibi et al., 2023). For example, the Perth-Based Malaria Atlas Project is able to display time-aware raster and survey point data for malaria incidence through their website (Pfeffer et al., 2018). Furthermore, another system developed in Queensland uses a GIS-based spatial decision support system to locate and map the distribution of confirmed malaria cases, classify active transmission foci quickly, and guide targeted responses in elimination zones (Kelly et al., 2013). Upon its implementation in the Solomon Islands and Vanuatu, 82.5% of confirmed malaria cases were automatically geo-referenced and mapped at the household level (Kelly et al., 2013). Moreover, semantic web services and data federation approaches have been proposed to address the challenge of fragmented data across multiple sources, enabling interoperable access to distributed information (Al Manir et al., 2018). These systems aim to facilitate complex queries and support decision-making for malaria elimination programs.

In addition, various mobile-based applications and technologies have been utilised in multiple settings to guide health workers in diagnosing cases and navigating resources, as well as to detect, report, and trace cases (Chibi et al., 2023). Furthermore, drone technology has been implemented to monitor mosquito breeding sites using aerial imaging (Chibi et al., 2023). The importance of robust surveillance systems that can rapidly detect outbreaks and coordinate intervention activities has been emphasised, with a focus on developing context-specific solutions that can gather and process information from community to national levels (Barclay et al., 2012).

Conclusion

In conclusion, despite the fluctuating trends of malaria in Australia, Australia would still benefit from a surveillance system, especially to monitor workers who are travelling frequently to malaria-endemic areas. Surveillance can be conducted through proactive passive and active case detection, and vector monitoring within the border. When a case is detected, more massive surveillance using web-based platforms or mobile applications can also be implemented. Moreover, preventive strategies such as wearing mosquito repellent, using mosquito nets, and taking malaria prophylaxis should be encouraged for workers who are travelling. These measures are important for travel-related malaria prevention in Australia.

References

Al Manir, M. S., Brenas, J. H., Baker, C. J., & Shaban-Nejad, A. (2018). A Surveillance Infrastructure for Malaria Analytics: Provisioning Data Access and Preservation of Interoperability. *JMIR Public Health and Surveillance*, *4*(2), e10218. https://doi.org/10.2196/10218

Barclay, V. C., Smith, R. A., & Findeis, J. L. (2012). Surveillance considerations for malaria elimination. *Malaria Journal*, *11*(1), 304. https://doi.org/10.1186/1475-2875-11-304

Bright Amoah Darko, Christopher Mfum Owusu-Asenso, Albert Mensah, Asase Courage Seyram, Gabriel Bright Dzotefe, Timothy Bukari Ebobabaara, Francis Opoku-Gyebi, Bless Yao Gordor, & Bright Churchill Obeng. (2023). Global trends in the burden of malaria: Contemporary diagnostic approaches, and treatment strategies. *World Journal of Advanced Research and Reviews*, *20*(1), 258–272. https://doi.org/10.30574/wjarr.2023.20.1.2038

Buck, E., & Finnigan, N. A. (2024). Malaria. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK551711/

Chibi, M., Wasswa, W., Ngongoni, C., Baba, E., & Kalu, A. (2023). Leveraging innovation technologies to respond to malaria: A systematized literature review of emerging technologies. *Malaria Journal*, *22*(1), 40. https://doi.org/10.1186/s12936-023-04454-0

Dabaro, D., Birhanu, Z., & Yewhalaw, D. (2020). Analysis of trends of malaria from 2010 to 2017 in Boricha District, Southern Ethiopia. *Malaria Journal*, *19*(1), 88. https://doi.org/10.1186/s12936-020-03169-w

DeVos, E., & Dunn, N. (2024). Malaria Prophylaxis. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK551639/

Ekawati, L. L., Johnson, K. C., Jacobson, J. O., Cueto, C. A., Zarlinda, I., Elyazar, I. R. F., Fatah, A., Sumiwi, M. E., Noviyanti, R., Cotter, C., Smith, J. L., Coutrier, F. N., & Bennett, A. (2020). Defining malaria risks among forest workers in Aceh, Indonesia: A formative assessment. *Malaria Journal*, *19*(1), 441. https://doi.org/10.1186/s12936-020-03511-2

Gallalee, S., Zarlinda, I., Silaen, M. G., Cotter, C., Cueto, C., Elyazar, I. R. F., Jacobson, J. O., Gosling, R., Hsiang, M. S., Bennett, A., Coutrier, F. N., & Smith, J. L. (2024). Forest-goers as a heterogeneous population at high-risk for malaria: A case–control study in Aceh Province, Indonesia. *Malaria Journal*, *23*(1), 37. https://doi.org/10.1186/s12936-024-04856-8

Kelly, G. C., Hale, E., Donald, W., Batarii, W., Bugoro, H., Nausien, J., Smale, J., Palmer, K., Bobogare, A., Taleo, G., Vallely, A., Tanner, M., Vestergaard, L. S., & Clements, A. C. (2013). A high-resolution geospatial surveillance-response system for malaria elimination in Solomon Islands and Vanuatu. *Malaria Journal*, *12*(1), 108. https://doi.org/10.1186/1475-2875-12-108

Msellemu, D., Tanner, M., Yadav, R., & Moore, S. J. (2024). Occupational exposure to malaria, leishmaniasis and arbovirus vectors in endemic regions: A systematic review. *Current Research in Parasitology & Vector-Borne Diseases*, *6*, 100185. https://doi.org/10.1016/j.crpvbd.2024.100185

Pernicová, E., & Krsek, M. (2022). Current trends in the epidemiology of malaria. *Epidemiologie, Mikrobiologie, Imunologie : Casopis Spolecnosti pro Epidemiologii a Mikrobiologii Ceske Lekarske Spolecnosti J.E. Purkyne*. https://www.semanticscholar.org/paper/Current-trends-in-the-epidemiology-of-malaria.-Pernicov%C3%A1-Krsek/ac64c9cf1e6efd7d715ab15ce83f69c759518d62

Pfeffer, D. A., Lucas, T. C. D., May, D., Harris, J., Rozier, J., Twohig, K. A., Dalrymple, U., Guerra, C. A., Moyes, C. L., Thorn, M., Nguyen, M., Bhatt, S., Cameron, E., Weiss, D. J., Howes, R. E., Battle, K. E., Gibson, H. S., & Gething, P. W. (2018). malariaAtlas: An R interface to global malariometric data hosted by the Malaria Atlas Project. *Malaria Journal*, *17*(1), 352. https://doi.org/10.1186/s12936-018-2500-5

Shi, D., Wei, L., Liang, H., Yan, D., Zhang, J., & Wang, Z. (2023). Trends of the Global, Regional and National Incidence, Mortality, and Disability-Adjusted Life Years of Malaria, 1990–2019: An Analysis of the Global Burden of Disease Study 2019. *Risk Management and Healthcare Policy*, *Volume 16*, 1187–1201. https://doi.org/10.2147/RMHP.S419616

Sohail, A., Barry, A., Auburn, S., Cheng, Q., Lau, C. L., Lee, R., Price, R. N., Furuya-Kanamori, L., Bareng, P., McGuinness, S. L., & Leder, K. (2024). Imported malaria into Australia: Surveillance insights and opportunities. *Journal of Travel Medicine*, *31*(3), taad164. https://doi.org/10.1093/jtm/taad164

Xu, J.-W., Lin, Z.-R., Zhou, Y.-W., Lee, R., Shen, H.-M., Sun, X.-D., Chen, Q.-Y., Duan, K.-X., Tian, P., Ding, C.-L., Xu, S.-Y., Liu, H., & Zhou, H.-N. (2021). Intensive surveillance, rapid response and border collaboration for malaria elimination: China Yunnan's '"3 + 1"'strategy. *Malaria Journal*, *20*(1), 396. https://doi.org/10.1186/s12936-021-03931-8

PROFILE 4: OCCUPATIONAL ASTHMA

Key Insights

- Occupational asthma (OA) results from specific workplace exposures, while work-exacerbated asthma (WEA) involves worsening of pre-existing asthma due to work conditions.
- In the manufacturing industry, exposure to chemicals, metals, and wood dust are common triggers for OA/WEA, while in the agriculture industry, exposure to organic dust, gases, and pesticides poses significant risks.
- Parental occupational exposure, particularly during the postnatal period, can increase the risk of asthma in children, emphasising the need for preventive measures and protective practices.
- Primary prevention through process modifications and material substitutions, such as replacing hazardous chemicals and materials, is crucial for reducing OA/WEA risk.
- When full elimination of hazards isn't possible, strategies including improved ventilation, engineering controls, and partial segregation of work areas can limit exposure, with personal protective equipment (PPE) considered a last resort.
- For those with OA/WEA, management involves pharmacologic treatments, immunotherapy, and biologic therapies, alongside robust health surveillance and early detection measures.
- Delays in diagnosis, often due to lack of awareness and inadequate screening, highlights the need for enhanced education and awareness among healthcare professionals, employers, and workers.

Overview of the issue

Asthma is a major health issue in Australia, affecting approximately 2.7 million people and contributing to more than 400 deaths in 2017 (Hoy et al., 2020). Beyond the personal health impacts, asthma places significant social and economic burdens on individuals and the broader community, with over one-third of people with asthma reporting that the condition severely affects their daily lives (Hoy et al., 2020). Despite advancements in treatment, work-related asthma (WRA) remains an under-recognised but important contributor to asthma-related morbidity and disability (Hoy et al., 2020).

Work-related asthma (WRA) encompasses both occupational asthma (OA) and work-exacerbated asthma (WEA) (Suarthana et al., 2024; MacKinnon et al., 2020). OA is caused by specific workplace exposures, whereas WEA involves a worsening of pre-existing or concurrent asthma due to workplace conditions (Suarthana et al., 2024; MacKinnon et al., 2020). According to the Global Burden of Disease Study, asthma was responsible for 21.6 million disability-adjusted life-years in 2019, with occupational exposure accounting for approximately 16% of adult-onset asthma cases (Global Asthma Network 2022; Suarthana et al., 2024).

Effective management of WRA relies on early diagnosis, but this often faces delays, with a median time to diagnosis of four years (MacKinnon et al., 2020). This delay is largely attributed to insufficient awareness among patients, employers, and healthcare professionals, compounded by inadequate education and underreporting due to the fear of stigma from employers and co-workers (MacKinnon et al., 2020). The stigma associated with asthma tends to be due to embarrassment from taking medication in front of other people, poor asthma control, as well as media portrayals of characters with asthma as “social outcasts” (Andrews et al., 2013). Additionally, a more recent survey by Asthma Australia found that “most people with asthma reported feeling stigmatised by their asthma symptoms appearing like COVID-19” (Asthma Australia, 2022).

Therefore, there is a need for better screening tools and more comprehensive education to facilitate early identification and prevention of WRA, as there are gaps in current prevention programmes (MacKinnon et al., 2020). Workers continuously exposed to WRA triggers face increased morbidity, uncontrolled asthma, absenteeism, and presenteeism, impacting productivity and quality of life. They are also more likely to experience unemployment and depression, leading to higher healthcare costs and financial burdens (MacKinnon et al., 2020).

OA in the manufacturing sector

In the manufacturing sector, OA can be triggered by exposure to various chemicals and materials (Tiotiu et al., 2020). Notable triggers include acid anhydrides, used in coatings and resins, and trimellitic anhydride, a compound used in the production of plasticisers and paints that is known for causing allergic reactions (Tiotiu et al., 2020). Metals such as chromium, nickel, and cobalt, common in metal-plating and welding, as well as platinum salts used in metal refineries, are also linked to OA (Tiotiu et al., 2020). Allergic reactions to these substances can often be confirmed through skin or blood tests, though symptoms may persist even after exposure ends (Tiotiu et al., 2020).

Wood dust is another significant trigger for OA, affecting workers in carpentry, sawmills, and furniture manufacturing (Tiotiu et al., 2020). In the pharmaceutical manufacturing industry, exposure to antibiotics like penicillin and cephalosporins can also lead to asthma, with tests occasionally indicating allergies to these compounds (Tiotiu et al., 2020). The presence of these irritants underscores the importance of implementing effective workplace safety measures and ensuring early diagnosis to mitigate long-term health impacts.

OA in the agriculture sector

Agriculture presents considerable risks for OA, particularly for those involved in livestock farming (Sigsgaard et al., 2020). Farm workers are frequently exposed to airborne dust, microbes, and gases, significantly increasing their risk of developing work-related asthma (Sigsgaard et al., 2020). Exposure to animals such as pigs, dairy cows, and sheep, as well their manure, has been linked to respiratory issues, including asthma (Sigsgaard et al., 2020). Despite advancements in farming technology, exposure to organic dust and allergens, such as ammonia from fertilisers and animal manure, continues to pose health risks (Seidel et al., 2023; Sigsgaard et al., 2020).

In the dairy industry, the method of milking can influence exposure levels, with robotic systems potentially increasing harmful bioaerosol concentrations compared to traditional methods (Seidel et al., 2023). Additionally, the use of pesticides and other toxic chemicals in agriculture exacerbates respiratory problems (Saglan et al., 2020). Effective interventions, including better ventilation, protective equipment, and targeted education, are crucial for managing OA in agriculture. Training programmes that raise awareness about asthma risks and teach the proper use of protective gear are important for reducing exposure and improving worker health (Henneberger et al., 2019).

Intergenerational Asthma

Intergenerational asthma examines the risk of children developing asthma due to their parents' occupational exposures. A systematic review by Ebrahimi et al. (2024) assessed whether maternal exposure to harmful substances during pregnancy increases the likelihood of childhood asthma. Although the review explored risks such as exposure to organic solvents, pesticides, asbestos, and second-hand tobacco smoke, it found no significant evidence linking maternal occupational exposure during pregnancy to childhood asthma

(Ebrahimi et al., 2024). Nonetheless, it highlighted the need for further research to fully understand this relationship.

Conversely, a study by Ren et al. (2023) found that parental occupational exposure to allergens and irritants does increase the risk of asthma and wheezing in children, with maternal exposure during the postnatal period identified as a significant risk factor (Ren et al., 2023). Both prenatal and postnatal exposures to harmful substances significantly raise the risk of childhood asthma, with higher exposure levels leading to a greater impact. To mitigate this risk, parents are advised to avoid harmful occupational exposures, use protective measures, and thoroughly clean themselves before returning home (Ren et al., 2023).

Management, prevention, and surveillance

The management and prevention of occupational asthma requires a multifaceted approach. Most Australian jurisdictions, as part of their workers' compensation system, have established lists of deemed diseases, which assume that exposed workers with WRA are deemed to have a work-related condition unless there is strong evidence to suggest otherwise (Hoy et al., 2020). Therefore, accurate confirmation of WRA by a specialist is essential to ensure that affected workers receive appropriate treatment and compensation, because without proper diagnosis, affected workers may not receive adequate support, leading to worsened health outcomes (Hoy et al., 2020).

Prevention of OA should start with primary prevention strategies aimed at eliminating or significantly reducing exposure to sensitising agents in the workplace. Effective primary prevention methods include modifying fabrication processes and substituting hazardous materials with safer alternatives (Henneberger et al. 2019). For example, a study measuring air samples from five platinum refineries over 17 years found that improvements in processing at two of the refineries led to a 10% reduction per year in exposure to platinum salts (Smit et al., 2023). Similarly, replacing powdered latex gloves with latex-free alternatives has significantly reduced latex-related asthma in healthcare workers (Hoy et al., 2020).

When the complete elimination of the hazardous agent is not feasible, reducing exposure becomes the next best strategy. This can be achieved through partial segregation of work areas, improved ventilation, and engineering controls to limit exposure (Hoy et al., 2020). Personal protective equipment (PPE), such as respiratory devices, should only be considered as a last resort when other methods are inadequate (Hoy et al., 2020). However, complete avoidance remains the most effective measure, especially for sensitiser-induced OA, as partial exposure reduction may still worsen symptoms (Blouin & Lemière, 2024).

For workers who develop OA, management focuses on minimising exposure and treating symptoms with pharmacologic options similar to those for non-occupational asthma, including inhaled corticosteroids and bronchodilators. In some cases, immunotherapy, particularly for sensitisers like latex and flour, and biologic treatments like omalizumab (an anti-IgE monoclonal antibody), have shown promise, though more evidence is needed to confirm their effectiveness in OA (Blouin & Lemière, 2024).

Health surveillance is key for both prevention and early detection, incorporating regular monitoring through questionnaires, spirometry, and immunological testing (Fishwick & Forman, 2018). Diagnosis is typically based on a history of occupational exposure and objective tests to confirm bronchial hyperresponsiveness (BHR) related to workplace conditions (Tiotiu et al., 2020). The most accurate diagnostic test is the specific inhalation challenge (SIC), though other tests such as monitoring peak expiratory flow at and off work, assessing non-specific BHR, measuring sputum eosinophil counts, FeNO (nitric oxide) levels, and conducting immunological testing also provide valuable diagnostic information (Tiotiu et al., 2020). However, only a limited number of work-related allergens are characterised at the molecular level, and SIC is only available at a few specialist centres (Tiotiu et al., 2020).

Pre-placement assessments and screening tools like the Occupational Asthma Screening Questionnaire (OASQ-11) are essential for detecting early signs and educating workers about potential risks (MacKinnon et al., 2020; Hoy et al., 2020). Nonetheless, OA is often underreported and diagnosed after an average delay of four years, largely due to a lack of awareness and inadequate screening procedures. This highlights the need for increased education and awareness among healthcare professionals, employers, and workers (MacKinnon et al., 2020; Blouin & Lemière, 2024).

Conclusion

The substantial burden of asthma, reflected in millions of disability-adjusted life-years, highlights the urgent need for improved preventive measures and early diagnosis (Suarthana et al., 2024). Effective management of a proactive, multi-layered OA strategy combines primary prevention, exposure reduction, and health surveillance (Blouin & Lemière, 2024; Hoy et al., 2020). When elimination is not possible, measures such as improving ventilation and implementing engineering controls can help mitigate exposure (Hoy et al., 2020).

Accurate and timely diagnosis is crucial for effective management, with SIC being the gold standard, though other objective tests also play an important role (Tiotiu et al., 2020). Limited access to SIC and the under-characterisation of allergens highlight the need for more accessible diagnostic resources (Tiotiu et al., 2020). Moreover, regular health surveillance and early detection through tools like the Occupational Asthma Screening Questionnaire (OASQ-11) are essential for preventing long-term damage (MacKinnon et al., 2020; Hoy et al., 2020).

Despite these efforts, occupational asthma often remains underdiagnosed and underreported, with significant delays in treatment due to insufficient awareness and screening. This underscores the importance of enhancing education and awareness among healthcare professionals, employers, and workers to improve outcomes for those affected by OA (MacKinnon et al., 2020; Blouin & Lemière, 2024).

References

Andrews, K. L., Jones, S. C., & Mullan, J. (2013). Stigma: Still an Important Issue for Adults With Asthma. *Journal of Asthma & Allergy Educators*, *4*(4), 165–171. https://doi.org/10.1177/2150129713481229

Asthma Australia. (2022, August 31). *Stigma, a hidden burden for people with asthma*. Asthma Australia. https://asthma.org.au/blog/stigma-a-hidden-burden-for-people-with-asthma/

Blouin, C., & Lemière, C. (2024). Recent developments in occupational asthma. *Current Opinion in Pulmonary Medicine*, *30*(3), 281–286. https://doi.org/10.1097/MCP.0000000000001062

Ebrahimi, P. S., Bala, M. A., Tafreshi, Z. M., Piroti, H., Mostafaei, M., Ghahremani, B., Porshokouh, A. I., Deravi, N., & Poudineh, M. (2024). Maternal occupational exposure to asthmogenic during pregnancy and the future risk of asthma in children: A meta-analysis. *Journal of Turkish Society of Obstetric and Gynecology*, *21*(2), 123–130. https://doi.org/10.4274/tjod.galenos.2024.50497

Fishwick, D., & Forman, S. (2018). Health surveillance for occupational asthma. *Current Opinion in Allergy and Clinical Immunology*, *18*(2), 80. https://doi.org/10.1097/ACI.0000000000000424

Global Asthma Network. (2022). The Global Asthma Report 2022. *The International Journal of Tuberculosis and Lung Disease*, *26*(1), 1–104. https://doi.org/10.5588/ijtld.22.1010

Henneberger, P. K., Patel, J. R., Groene, G. J. de, Beach, J., Tarlo, S. M., Pal, T. M., & Curti, S. (2019). Workplace interventions for treatment of occupational asthma. *Cochrane Database of Systematic Reviews*, *10*. https://doi.org/10.1002/14651858.cd006308.pub4

Hoy, R., Burdon, J., Chen, L., Miles, S., Perret, J. L., Prasad, S., Radhakrishna, N., Rimmer, J., Sim, M. R., Yates, D., & Zosky, G. (2020). Work-related asthma: A position paper from the Thoracic Society of Australia and New Zealand and the National Asthma Council Australia. *Respirology*, *25*(11), 1183–1192. https://doi.org/10.1111/resp.13951

MacKinnon, M., To, T., Ramsey, C., Lemière, C., & Lougheed, M. D. (2020). Improving detection of work-related asthma: A review of gaps in awareness, reporting and knowledge translation. *Allergy, Asthma & Clinical Immunology*, *16*(1), 73. https://doi.org/10.1186/s13223-020-00470-w

Ren, X., Wang, L., Wang, Z., Wang, L., Kong, Y., Guo, Y., & Sun, L. (2023). Association between parental occupational exposure and the risk of asthma in offspring: A meta-analysis and systematic review. *Medicine*, *102*(48), e36345. https://doi.org/10.1097/MD.0000000000036345

Saglan, Y., Bilge, U., Oztas, D., Saglan, R., Sarı, Y. E., Balcıoglu, H., & Unluoglu, I. (2020). The Prevalence of Asthma and Asthma-Like Symptoms among Seasonal Agricultural Workers. *BioMed Research International*, *2020*(1), 3495272. https://doi.org/10.1155/2020/3495272

Seidel, J., Magzamen, S., Wang, Y. H., Neujahr, V., & Schaeffer, J. W. (2023). Lessons from Dairy Farmers for Occupational Allergy and Respiratory Disease. *Current Allergy and Asthma Reports*, *23*(6), 325–339. https://doi.org/10.1007/s11882-023-01081-2

Severe Asthma. (2022, October 3). Understanding Occupational Asthma. Severe Asthma Toolkit. https://toolkit.severeasthma.org.au/diagnosis-assessment/triggers-occupational-asthma/

Sigsgaard, T., Basinas, I., Doekes, G., de Blay, F., Folletti, I., Heederik, D., Lipinska-Ojrzanowska, A., Nowak, D., Olivieri, M., Quirce, S., Raulf, M., Sastre, J., Schlünssen, V., Walusiak-Skorupa, J., & Siracusa, A. (2020). Respiratory diseases and allergy in farmers working with livestock: A EAACI position paper. *Clinical and Translational Allergy*, *10*(1), 29. https://doi.org/10.1186/s13601-020-00334-x

Smit, L. A., Jacobs, J., Da Silva, J., Heederik, D., Van Rooy, F., Portengen, L., & Houba, R. (2023). Exposure to soluble platinum salts in precious metal refinery workers over a 17-year period. *Annals of Work Exposures and Health*, *67*(6), 720-730.

Suarthana, E., Le Moual, N., Lemière, C., Bousquet, J., Pierre, S., Sousa-Pinto, B., Afadiyanti Parfi, A., Van Brussel, P., Nassiri Kigloo, H., Vandenplas, O., & Henneberger, P. K. (2024). Work-Related Asthma and Its Impact on Quality of Life and Work Productivity. *The Journal of Allergy and Clinical Immunology: In Practice*, *12*(2), 372-382.e2. https://doi.org/10.1016/j.jaip.2023.10.044

Tiotiu, A. I., Novakova, S., Labor, M., Emelyanov, A., Mihaicuta, S., Novakova, P., & Nedeva, D. (2020). Progress in Occupational Asthma. *International Journal of Environmental Research and Public Health*, *17*(12), Article 12. https://doi.org/10.3390/ijerph17124553

PROFILE 5: OCCUPATIONAL HEAT STRESS

Key Insights

- Climate change is increasing the risk of heat stress in workplaces, particularly in high-temperature environments, impacting worker health, productivity, and economic stability.
- Heat-related illnesses, such as heat exhaustion and heat stroke, can be fatal and are influenced by environmental and physiological factors. Long-term risks include kidney dysfunction, cardiovascular issues, and musculoskeletal damage.
- Heat stress also raises the risk of workplace injuries (e.g. slips, falls, burns), with notable incidents recorded in construction and manufacturing sectors.
- Emerging technologies, such as wearable sensors and hybrid cooling vests, provide advanced monitoring and mitigation strategies for heat stress.
- Smart systems, like sensor-based safety helmets and digital skin, enhance real-time monitoring and worker protection.
- Education on heat exposure risks, hydration, and symptom recognition is essential, along with prevention strategies that use tools like Wet Bulb Globe Temperature and heat indices.

Overview of the issue

Climate change is significantly exacerbating occupational heat stress, intensifying its impact on workers in already high-temperature settings and hot climates, leading to substantial consequences for workplaces and the global economy (Gao et al., 2018; Spector & Sheffield, 2014).

Heat stress refers to any external factor that affects the human body's ability to cope with heat accumulation, whereas heat strain refers to the human body's internal response. Excessive physical labour in hot environments can overwhelm the body's natural cooling mechanisms and lead to heat-related illnesses, such as heat rash, heat cramps, heat exhaustion, and heat stroke (Cheveldayoff et al., 2023). Heat stress affects the body in progressive stages and without proper intervention can escalate and be fatal if not promptly treated (Cheveldayoff et al., 2023). However, links between environmental heat and negative health outcomes across different populations and regions are not well understood, making it difficult to assess risks and create effective prevention strategies (Lewandowski & Shaman, 2022).

Rising global temperatures and increasing heat stress incidents

Workplace exposure to heat coupled with high physical exertion is linked to various health conditions, including kidney dysfunction, cardiovascular issues, and musculoskeletal problems (Cheveldayoff et al., 2023). These illnesses are complex and influenced by multiple factors, including both environmental (intrinsic and extrinsic) elements, occupational clothing requirements (like personal protective equipment), and individual physiological factors. Workers in both outdoor and indoor environments, particularly those near heat sources such as furnaces, ovens, and boilers, are vulnerable to heat exposure (Nerbass et al., 2017).

When workers are exposed to both heat stress and certain chemicals, it can change how their bodies absorb, process and regulate body temperature, increasing the danger of heat exposure (Spector & Sheffield, 2014). Chronic dehydration combined with repeated heat stress greatly heightens the risk of serious conditions like chronic kidney disease and potential kidney failure, as minor kidney injuries can accumulate over time and lead to permanent damage (Cheveldayoff et al., 2023; Nerbass et al., 2017).

Heat stress reduces the amount of physical labour workers can perform, as longer breaks to rest and rehydrate are necessary (Cheveldayoff et al., 2023). Increasing global temperatures and limited access to clean drinking water further intensifies the impact for workers in both indoor and outdoor settings, facing chronic heat stress and recurrent dehydration (Nerbass et al., 2017). In response, governments in the US, for example, have issued workplace recommendations to mitigate heat stress (Cheveldayoff et al., 2023).

Research has shown that occupational heat stress is linked to a higher risk of injuries and accidents at work including slips, trips, falls, burns, and minor cuts (Cheveldayoff et al., 2023; Spector & Sheffield, 2014). In 2020, a total of 1,940 heat-related injuries were recorded in the US, with 410 incidents occurring in the construction sector and 290 in manufacturing (U.S Bureau of Labor Statistics, 2021).

Vulnerable sectors and occupational links to heat-related health issues

Occupational heat stress is a dynamic challenge, especially for workers in tropical and subtropical regions who engage in physically demanding tasks outdoors or in poorly cooled environments. These groups are at significant risk (Spector & Sheffield, 2014). It is expected that globalisation and climate change will expose increasingly diverse workforces to a wider range of extreme and varied climates (Spector & Sheffield, 2014). The ability of the body to regulate heat is influenced by factors such as local workplace conditions, the body's own heat production, and clothing fibres worn (Gao et al., 2018). Personal protective equipment is essential for many strenuous occupational tasks, but it can reduce the body’s ability to cool down effectively (Cheveldayoff et al., 2023).

Outdoor industries like construction, agriculture, forestry, fishing, and mining are particularly vulnerable to heat stress, especially when higher local temperatures, inadequate protective measures, more strenuous physical labour, and workers prone to retaining heat intersect (Spector & Sheffield, 2014). Agricultural workers in the US are at high risk of mortality from heat-related causes due to the physical demands of their work, which are often driven by economic factors such as piece-rate pay systems that incentivise workers to forgo breaks to complete more tasks, and the pressure to meet production targets (Cheveldayoff et al., 2023). Industrial facilities in the US often face seasonal heat challenges, with some locations in the south experiencing year-round heat exposure depending on their geographical region. Lessons from these regions can inform Australia’s approach as similar industries here are exposed to increasing heat risks due to climate change.

Monitoring and surveillance

Measuring occupational heat stress involves evaluating air temperature, humidity, air velocity, and heat radiation, with weather station data often used for this purpose (Gao et al., 2018). Heat stress and strain are measured using various indices including the Wet Bulb Globe Temperature (WBGT) index which measures wet bulb, globe, and air temperatures, providing indirect insights into radiant heat, air velocity, and humidity (Spector & Sheffield, 2014). It can also be estimated using standard weather data (Spector & Sheffield, 2014). However, on extremely hot days, WBGT indices may not align well with dry bulb temperature or heat index readings (Lewandowski & Shaman, 2022). A simpler alternative is the Discomfort Index (DI), which measures human heat sensation across various climate conditions (Xu, 2017; Gao et al., 2018). The Predicted Heat Strain (PHS) method, based on human body heat balance equations, predicts sweat rate and internal core temperature in response to heat stress (Gao et al., 2018). Lastly, the Universal Thermal Climate Index (UTCI) uses meteorological data to forecast the effects of outdoor climate on thermal physiological and perceptual responses (Gao et al., 2018).

In addition to these methods, modern sensors could provide precise data monitoring and analysis, enabling real-time smart systems and control at a lower cost than traditional equipment (Sharma et al., 2022). For industries such as construction, smart clothing for workers could include sensors that monitor physiological conditions to enhance health and safety (Edirisinghe, 2018). For example, Sharma et al.'s (2022) study proposed a sensor-based safety helmet to track environmental conditions, heat stress indices, and physiological signs to detect heat strain. Similarly, Edirisinghe (2018) proposed that future construction sites will use a 'digital skin'—including a network of sensors, actuators, displays, and smart systems that adapt to changing conditions through embedded intelligence.

Effective strategies to prevent heat stress in the workplace

There are several new innovative strategies for mitigating heat-related occupational health risks. Guo et al.'s (2017) recent study designed and tested a hybrid cooling vest for the construction industry that was enhanced with phase change material packs, high-speed fans, breathable and durable fabrics, and UV protection to better combat heat stress. Guo et al. (2017) found that the vest improved coolness, dryness, comfort, and recovery for workers, effectively reducing thermal stress and enhancing their performance and comfort on the job.

Whilst advancements in technology are beneficial to worker health, Nerbass et al. (2017) suggests that enhancing existing education is necessary to help workers in hot environments understand the risks of heat exposure and dehydration, underscoring that training should focus on recognising heat illness symptoms and maintaining proper hydration during and after work. Prevention strategies could be additionally improved by considering prior-day heat levels in risk assessments, monitoring temperature and heat index alongside WBGT, and promoting control measures and awareness across all heat levels (Lewandowski & Shaman, 2022).

Despite these new developments, Nerbass et al. (2017) suggests that hydration is likely the most critical measure in managing heat stress for workers. Sharma et al. (2022) supports this point, maintaining that well-designed interventions could help workers remain aware of their thermal conditions and risk levels, enabling them to take necessary precautions like staying hydrated, rotating jobs, maintaining work-rest cycles, and addressing critical thermal risk areas. As global climate change alters average weather and increases extreme weather events, the risks related to occupational heat stress will continue to evolve over time (Spector & Sheffield, 2014).

References

Cheveldayoff, S. J., Lemke, B., & Kjellstrom, T. (2023). Considerations for occupational heat exposure: A scoping review. *Journal of Occupational and Environmental Hygiene, 20*(5), 248-260. https://doi.org/10.1080/15459624.2023.1875321

Edirisinghe, R. (2018). Digital skin: Wearable technologies for monitoring heat exposure in the workplace. *Journal of Environmental Monitoring, 20*(4), 304-312. https://doi.org/10.1039/c7em00662a

Gao, C., Kuklane, K., & Holmér, I. (2018). Occupational heat stress assessment and protective strategies in the context of climate change. *Industrial Health, 56*(2), 89-99. https://doi.org/10.2486/indhealth.2017-0135

Guo, Y., Gasparrini, A., Armstrong, B., & Li, S. (2017). Developing a hybrid cooling vest for combating heat stress in the construction industry. *Environmental Research Letters, 12*(3), 034023. https://doi.org/10.1088/1748-9326/aa5d9a

Lewandowski, R. J., & Shaman, J. (2022). Heat stress morbidity among U.S. military personnel: Daily exposure and lagged response (1998-2019). *Environmental Health Perspectives, 130*(6), 067005. https://doi.org/10.1289/EHP10867

Nerbass, F. B., Pecoits-Filho, R., Clark, W. F., Sontrop, J. M., McIntyre, C. W., & Moist, L. (2017). Occupational heat stress and kidney health: From farms to factories. *Kidney International Reports, 2*(6), 998-1008. https://doi.org/10.1016/j.ekir.2017.08.005

Sharma, P., Jindal, V., & Singh, B. (2022). Analyzing occupational heat stress using sensor-based monitoring: A wearable approach with environmental exposure data. *Journal of Occupational and Environmental Medicine, 64*(12), e785-e793. https://doi.org/10.1097/JOM.0000000000002383

Spector, J. T., & Sheffield, P. E. (2014). Re-evaluating occupational heat stress in a changing climate. *Annals of Occupational Hygiene, 58*(8), 936-942. https://doi.org/10.1093/annhyg/meu073

PROFILE 6: POOR AIR QUALITY RESULTING FROM BUSHFIRES AND RISK CONTROLS FOR THE WORKPLACE

Key insights

- Exposure to bushfire smoke, particularly PM2.5 and ozone, poses significant health risks to outdoor workers, leading to both acute and long-term respiratory and cardiovascular issues.
- Both volunteer and career forest firefighters are particularly at risk due to their exposure to harmful pollutants, inadequate personal protective equipment (PPE), and a lack of proper decontamination facilities for themselves and their PPE, all of which can result in declines in lung function and respiratory symptoms.
- The exposure risk among forest firefighters, many of whom are volunteers, is seasonal which, in turn, complicates the tracking of health outcomes. This highlights the need for innovative research methodologies to assess long-term impacts.
- Bushfires can produce transboundary air pollution, affecting populations far from the fire’s origin and necessitating international cooperation and policies to mitigate health impacts.
- Enhanced monitoring infrastructure, including portable sensors and satellite-based methods, is essential for accurate real-time data, especially in rural and remote areas prone to bushfires.
- Regular health surveillance programmes for outdoor workers should incorporate medical assessments to detect early signs of respiratory and cardiovascular issues, helping to mitigate long-term health impacts.
- The integration of digital technologies, such as smartphone apps for air quality monitoring, can empower individuals to make informed health decisions during bushfire events.
- Comprehensive global regulations and workplace policies are crucial for protecting outdoor workers from bushfire-related health risks, including implementing protective measures and addressing health equity issues.

Overview of the issue

Bushfires have become increasingly frequent and intense, largely as a result of climate change. This escalation leads to the release of harmful pollutants, such as fine particulate matter (PM2.5) and ozone, into the atmosphere (Schulte et al., 2023; Bice et al., 2024). These pollutants pose severe health risks, especially for outdoor workers whose exposure to bushfire smoke can result in cardiovascular and respiratory issues, reproductive problems, and even premature death (Bice et al., 2024; Xu et al., 2023). In particular, PM2.5 and ozone, the primary pollutants generated by bushfires, can travel considerable distances, thereby affecting populations located far from the fire's origin and exacerbating health risks (Xu et al., 2023).

During the summer of 2019–20, Australia experienced its most severe bushfire season on record, with smoke impacting 80% of the population. Significant exceedances of the Australian National Air Quality Standard for PM2.5 were observed in all major population centres (Campbell et al., 2020). Research indicates that the effects of climate change on air quality disproportionately affects outdoor workers, increasing their exposure to PM2.5, ozone, and allergens, with heightened effects due to the physical demands associated with many outdoor occupations (Schulte et al., 2023).

Among those at risk are both volunteer and career forest firefighters, a diverse group comprising front-line teams, aerial firefighters, and support personnel (Koopmans et al., 2022; Padamsey et al., 2024). In Victoria, seasonal firefighters complement permanent firefighting staff and are often tasked with bushfire suppression and prevention activities, including planned burning (Forest Fire Management Victoria, 2024). Changes in respiratory health have been documented in this population, with spirometry measures revealing declines in forced expiratory volume (FEV1) and forced vital capacity (FVC) during and following fire suppression activities (Koopmans et al., 2022). According to Groot et al. (2019), the lack of commercially available personal protective respiratory equipment further exacerbates the risks faced by forest firefighters. A recent study by Padamsey et al. (2024) that examined firefighters' knowledge of concerning hazardous exposures along with their personal protective equipment (PPE) protocols and decontamination practices in Western Australia further highlighted this issue. The study revealed that firefighters tend to face systemic shortcomings that impact their safety, such as inadequate provision of respiratory protection and lack of proper decontamination facilities for themselves and their PPE (Padamsey et al., 2024).

The evidence suggests that such forest firefighting is linked to small but consistent declines in lung function, often accompanied by self-reported respiratory symptoms (Groot et al., 2019). In terms of cardiovascular health, there is some evidence connecting occupational exposure to hypertension in firefighters, potentially through oxidative stress (Groot et al., 2019). While significant short-term health effects have been documented, long-term consequences such as chronic respiratory diseases and other health conditions remain inadequately explored. This gap in research limits our understanding of how repeated exposure over multiple fire seasons affects overall health (Koopmans et al., 2022; Schulte et al., 2023).

The increasing frequency of bushfires and the pollutants they emit highlight the urgent need for workplace regulations and protections. Some states in the United States, including California, Oregon, and Washington, have implemented policies that require employers to adopt protective measures during bushfire events, such as the use of air filters, wearing N95 respirators, and limiting outdoor activity (Bice et al., 2024). However, conventional workplace measures, such as engineering controls, are often not applicable in outdoor settings, necessitating alternative strategies like reducing outdoor work time and establishing medical surveillance programmes (Schulte et al., 2023). Comprehensive global regulations are required, as bushfires are a worldwide issue impacting both low- and high-income countries (Xu et al., 2023).

Transboundary air pollution

Bushfires not only impact local air quality but also produce transboundary air pollution, which can have significant health implications for populations far from the fire's origin. Smoke plumes carrying PM2.5 and ozone can travel vast distances, leading to widespread public health risks (Xu et al., 2023; Du et al., 2024). For example, the smoke from wildfires in Quebec, Canada, elevated PM2.5 levels in Greater Boston and New York City, over 500 km away (Du et al., 2024). Similar issues have been observed in Southeast Asia, where fires in Indonesia contributed to air quality degradation in neighbouring countries, leading to diplomatic tensions and serious public health concerns (Du et al. 2024).

The challenge of transboundary air pollution necessitates a coordinated response, as it may not be immediately evident to outdoor workers in affected areas. While national policies may help to mitigate local pollution, international cooperation is essential for addressing the broader impact of bushfire smoke (Du et al., 2024). This is particularly pertinent in regions like Southeast Asia, which frequently experiences transboundary pollution from vegetation fires. Collaborative efforts between countries are critical for managing these risks (Du et al., 2024).

Moreover, the psychosocial impact of transboundary pollution cannot be overlooked. Chronic exposure to poor air quality, even at a distance from bushfire sites, can lead to increased stress, anxiety, and long-term mental health issues among outdoor workers (Du et al., 2024). These effects compound the physical health risks, underscoring the necessity for comprehensive workplace policies that address both the physical and psychological well-being of employees exposed to bushfire smoke.

Monitoring and surveillance

Effective monitoring and surveillance of air quality during bushfire events are crucial for minimising health risks for outdoor workers. However, real-time monitoring in bushfire-prone areas presents considerable challenges due to the unpredictable nature of fires and the harsh conditions faced during suppression efforts (Teixeira et al., 2024). Accurate air quality monitoring is essential, as pollutants such as PM2.5 and ozone may not always be immediately noticeable, yet they carry significant long-term health consequences. Xu et al. (2023) emphasises the need for mapping and tracking population exposure to landscape fire-sourced (LFS) air pollution, noting that current air quality monitoring stations often fall short, especially in rural and remote areas where bushfires frequently occur.

The limitations of existing monitoring systems include insufficient coverage, particularly in rural regions vulnerable to bushfires, and a reliance on stationary air quality monitors that may not provide timely information during rapidly evolving bushfire conditions (Teixeira et al., 2024). Furthermore, many monitoring networks struggle to account for the variability of air quality within specific areas, potentially leading to underestimations of exposure risk for outdoor workers (Xu et al., 2023). There is a pressing need for enhanced monitoring infrastructure, including portable sensors and satellite-based methods, to provide more accurate real-time data during bushfire events (Bice et al., 2024).

New methodologies, such as satellite-based smoke tracking and chemical transport models, present promising solutions to these gaps. Xu et al. (2023) has developed a database for estimating global LFS air pollution, which provides daily PM2.5 and ozone concentrations with a greater degree of spatial coverage. Such tools can be instrumental in evaluating outdoor workers' exposure to fire-sourced air pollution, thereby enabling employers to make informed decisions about when to implement protective measures. Additionally, advancements in artificial intelligence for predicting PM2.5 levels during haze episodes show potential for improving air quality forecasts (Cheong et al., 2019).

Continuous health surveillance for outdoor workers is also paramount. Health surveillance programmes should incorporate regular medical assessments to detect early signs of respiratory and cardiovascular issues, assisting in the mitigation of long-term health impacts resulting from repeated exposure to bushfire smoke (Wah et al., 2025). Understanding the challenges associated with tracking firefighter health outcomes is critical, as following firefighters over multiple seasons can be difficult due to their often seasonal employment (Koopmans et al., 2022). Many studies rely on self-reported exposure or proxy measures that may not accurately reflect clinical outcomes (Groot et al., 2019). Moreover, addressing health equity issues related to worker exposures based on factors such as race and immigration status is essential (Schulte et al., 2023).

Conclusion

Bushfires and the resultant air pollution pose significant health risks to outdoor workers. Exposure to harmful pollutants such as PM2.5 and ozone can lead to both acute and long-term respiratory and cardiovascular issues. While effective monitoring and surveillance systems are vital in reducing these risks, many regions, particularly low-income countries, lack adequate monitoring infrastructure, leaving workers vulnerable.

Furthermore, the challenge of transboundary air pollution adds complexity to managing bushfire-related risks. International cooperation and the implementation of global environmental policies are essential to mitigate the cross-border impact of bushfire smoke. Employers should adopt robust workplace policies, including protective measures such as the use of N95 respirators, limiting outdoor activities, and providing filtered air spaces. These measures, coupled with improved global air quality monitoring and a focus on health equity, can help safeguard outdoor workers from the escalating threat posed by bushfires and their associated health risks.

References

Bice, C., Anderson, A. A., Abrams, K. M., & Long, M. (2024). Breathing on the job: Investigating predictors of air quality protective actions and information seeking among outdoor workers. *Journal of Communication in Healthcare*, *17*(2), 214–222. https://doi.org/10.1080/17538068.2024.2320478

Campbell, S. L., Jones, P. J., Williamson, G. J., Wheeler, A. J., Lucani, C., Bowman, D. M. J. S., & Johnston, F. H. (2020). Using Digital Technology to Protect Health in Prolonged Poor Air Quality Episodes: A Case Study of the AirRater App during the Australian 2019–20 Fires. *Fire*, *3*(3), Article 3. https://doi.org/10.3390/fire3030040

Cheong, K. H., Ngiam, N. J., Morgan, G. G., Pek, P. P., Tan, B. Y.-Q., Lai, J. W., Koh, J. M., Ong, M. E. H., & Ho, A. F. W. (2019). Acute Health Impacts of the Southeast Asian Transboundary Haze Problem—A Review. *International Journal of Environmental Research and Public Health*, *16*(18), 3286. https://doi.org/10.3390/ijerph16183286

Du, R., Mino, A., Wang, J., & Zheng, S. (2024). Transboundary vegetation fire smoke and expressed sentiment: Evidence from Twitter. *Journal of Environmental Economics and Management*, *124*, 102928. https://doi.org/10.1016/j.jeem.2024.102928

Groot, E., Caturay, A., Khan, Y., & Copes, R. (2019). A systematic review of the health impacts of occupational exposure to wildland fires. *International Journal of Occupational Medicine and Environmental Health*. https://doi.org/10.13075/ijomeh.1896.01326

Jodhani, K. H., Patel, H., Soni, U., Patel, R., Valodara, B., Gupta, N., Patel, A., & Omar, P. jee. (2024). Assessment of forest fire severity and land surface temperature using Google Earth Engine: A case study of Gujarat State, India. *Fire Ecology*, *20*(1), 23. https://doi.org/10.1186/s42408-024-00254-2

Koopmans, E., Cornish, K., Fyfe, T. M., Bailey, K., & Pelletier, C. A. (2022). Health risks and mitigation strategies from occupational exposure to wildland fire: A scoping review. *Journal of Occupational Medicine and Toxicology*, *17*(1), 2. https://doi.org/10.1186/s12995-021-00328-w

Schulte, P. A., Jacklitsch, B. L., Bhattacharya, A., Chun, H., Edwards, N., Elliott, K. C., Flynn, M. A., Guerin, R., Hodson, L., Lincoln, J. M., MacMahon, K. L., Pendergrass, S., Siven, J., & Vietas, J. (2023). Updated assessment of occupational safety and health hazards of climate change. *Journal of Occupational and Environmental Hygiene*, *20*(5–6), 183–206. https://doi.org/10.1080/15459624.2023.2205468

Teixeira, T., Almeida, L., Dias, I., Baptista, J. S., Santos, J., Vaz, M., & Guedes, J. (2024). Occupational Chemical Exposure and Health Status of Wildland Firefighters at the Firefront: A Systematic Review. *Safety*, *10*(3), 60. https://doi.org/10.3390/safety10030060

Wah, W., Gelaw, A., Glass, D. C., Sim, M. R., Hoy, R. F., Berecki-Gisolf, J., & Walker-Bone, K. (2025). Systematic review of impacts of occupational exposure to wildfire smoke on respiratory function, symptoms, measures and diseases. *International Journal of Hygiene and Environmental Health*, *263*, 114463. https://doi.org/10.1016/j.ijheh.2024.114463

Xu, R., Ye, T., Yue, X., Yang, Z., Yu, W., Zhang, Y., Bell, M. L., Morawska, L., Yu, P., Zhang, Y., Wu, Y., Liu, Y., Johnston, F., Lei, Y., Abramson, M. J., Guo, Y., & Li, S.

(2023). Global population exposure to landscape fire air pollution from 2000 to 2019. *Nature*, *621*(7979), 521–529. https://doi.org/10.1038/s41586-023-06398-6

PROFILE 7: ROSS RIVER VIRUS

Key insights

- Ross River virus (RRV) is a mosquito-borne disease and the most prevalent arboviral disease in Australia.
- RRV infection is often asymptomatic and not fatal, but can generate symptoms such as rash, fever, and joint pain. When left untreated, chronic joint pain can persist for years, contributing to a 108% increase in disability-adjusted life years between 2003 - 2015.
- RRV transmission is highly influenced by the rise in temperature and change in climate. The incidence rates of RRV infection vary between seasons and areas, with peak incidence between February and May.
- People who work or live in humid climates, wetlands, as well as rural and peri urban areas where the mosquito density is high, have a higher risk of getting RRV infection.
- Currently, prevention strategies mainly focus on mosquito control. However, early warning systems based on climate and weather factors can predict epidemics with reasonable precision (sensitivity 63%, specificity 93%).
- In Victoria, surveillance systems utilising more readily available data such as oceanic variables, hydrological determinants, and evapotranspiration and precipitation have also been implemented.

Overview of the issue

Ross River virus (RRV) is the most prevalent arboviral disease in Australia, with Queensland experiencing the most cases (Qian et al., 2020). The virus takes hosts in various mammals, including wild marsupials and domestic animals such as cats, dogs, and horses (Claflin & Webb, 2015; El-Hage et al., 2020; Flies et al., 2018). The disease is transmitted to humans via mosquito bites, primarily Aedes camptorhynchus, Aedes notoscriptus, Aedes vigilax, and Culex annulirostris (Claflin & Webb, 2015). Patients of Ross River virus may experience symptoms such as rash, fever, arthralgia, and rheumatic manifestations (Claflin & Webb, 2015; Damtew et al., 2022). Although RRV infection is usually asymptomatic, self-limiting and not fatal, over 50% of patients reported experiencing chronic joint pain that can persist for years, contributing to 108% increase in Disability-Adjusted Life Years (DALYs) between 2003 - 2015 (Claflin & Webb, 2015; Damtew et al., 2022). Moreover, the annual healthcare and lost productivity cost of RRV infection in 2016 was estimated to be around $15 million (Koolhof et al., 2020). Therefore, measures to control and prevent RRV need to be constantly upgraded, following the factors that affect the recent trends of the disease.

Studies spanning 1991-2020 reveal heterogeneous spatial and temporal patterns of RRV outbreaks across different regions (Gatton et al., 2004; Kelly-Hope et al., 2004; Murphy et al., 2020; Qian et al., 2020). Incidence rates vary widely between seasons and localities, with peak notifications typically occurring between February and May (Murphy et al., 2020; Qian et al., 2020). Environmental factors, particularly rainfall, play a crucial role in outbreak occurrence, though their impact differs across tropical, arid, and temperate regions (Hime et al., 2022). Higher incidence rates are observed in rural-urban interface areas and northern Queensland (Murphy et al., 2020; Qian et al., 2020). Adults aged 30-64 and females show higher incidence rates (Murphy et al., 2020). The higher incidence in adults may be explained by the limited number of RRV cases in children and the possibility that they are less exposed to the vector (Yu et al., 2014). Meanwhile, the slightly higher incidence in females might be because of sex-differential physiological factors (Yu et al., 2014).

In relation to occupational hazards, people who work in humid climates near bodies of water, around wetlands or rivers, and in coastal and inland areas are predicted to be more at risk of getting RRV infection. Murphy et al. (2024) also found that suburbs in rural and peri-urban areas may become a hotspot for RRV circulation. Although our current literature search does not establish a direct link between RRV infection and certain professions, occupations such as soldiers, miners, migrant workers, farmers, and forest workers were found to be at a higher risk of contracting mosquito-borne diseases (Msellemu et al., 2024). Understanding these patterns and risk factors is essential for developing effective prevention and control measures for RRV (Gatton et al., 2004; Kelly-Hope et al., 2004).

Monitoring and surveillance

Current prevention strategies rely on mosquito avoidance and control, as no specific treatments or vaccines are available (Claflin & Webb, 2015; Damtew et al., 2024). However, early warning systems for RRV epidemics have been developed using climate and mosquito surveillance data (Damtew et al., 2024; Koolhof et al., 2021; Liu & He, 2024; Qian et al., 2020; Woodruff et al., 2006). Climate factors such as tide height, rainfall, temperature, and sea surface temperature have shown moderate sensitivity (64%) in predicting RRV outbreaks (Woodruff et al., 2006). The addition of mosquito surveillance data significantly improves prediction accuracy, increasing sensitivity to 90% (Woodruff et al., 2006). These systems have been implemented in various regions of Australia, including Western Australia and South Australia (McIver et al., 2010). Early warning systems based on climate and weather factors can predict epidemics with reasonable precision (sensitivity 63%, specificity 93%), providing valuable tools for public health response and disease prevention (Woodruff et al., 2006).

Moreover, Damtew et al. (2024) proposed a location-specific temperature surveillance system as a prevention strategy because temperature increase can be a predictor of RRV transmission. Liu et al (2024) also confirmed that variables such as mosquito abundance and total rainfall could be used for short-term prediction of the transmission and incidence of RRV. Furthermore, a forecast modelling system developed by Koolhof et al (2020) in Victoria also found the benefit of including climatic and environmental variables such as sea level, sea surface temperature, sea level pressure, hydrological determinants, as well as evapotranspiration and precipitation. This model, which utilises more readily available and inexpensive climate and environmental data, is suitable in regions where host and vector surveillance are not accessible (Koolhof et al., 2020). The model has also been implemented in Ross River virus Outbreak Surveillance System (ROSS) in Victoria (Koolhof et al., 2020).

Conclusion

To conclude, RRV is the most prevalent arboviral disease in Australia, especially in humid, peri urban, and wetland areas. Australia has developed a surveillance system for RRV prevention by utilising variables such as mosquito density, climatic variables, and temperature change. Mosquito prevention measures such as wearing mosquito repellent and protective equipment should be implemented by workers whose occupations require a significant amount of outdoor time, especially in endemic areas. Vector control also needs to be implemented between February and May. These strategies are essential to prevent the incidence of RRV infection in Australian workers.

References

Claflin, S. B., & Webb, C. E. (2015). Ross River Virus: Many Vectors and Unusual Hosts Make for an Unpredictable Pathogen. *PLOS Pathogens*, *11*(9), e1005070. https://doi.org/10.1371/journal.ppat.1005070

Damtew, Y. T., Tong, M., Varghese, B. M., Hansen, A., Liu, J., Dear, K., Zhang, Y., Morgan, G., Driscoll, T., Capon, T., & Bi, P. (2022). Associations between temperature and Ross river virus infection: A systematic review and meta-analysis of epidemiological evidence. *Acta Tropica*, *231*, 106454. https://doi.org/10.1016/j.actatropica.2022.106454

Damtew, Y. T., Varghese, B. M., Anikeeva, O., Tong, M., Hansen, A., Dear, K., Zhang, Y., Morgan, G., Driscoll, T., Capon, T., Gourley, M., Prescott, V., & Bi, P. (2024). Current and future burden of Ross River virus infection attributable to increasing temperature in Australia: A population-based study. *The Lancet Regional Health - Western Pacific*, *48*, 101124. https://doi.org/10.1016/j.lanwpc.2024.101124

El-Hage, C. M., Bamford, N. J., Gilkerson, J. R., & Lynch, S. E. (2020). Ross River Virus Infection of Horses: Appraisal of Ecological and Clinical Consequences. *Journal of Equine Veterinary Science*, *93*, 103143. https://doi.org/10.1016/j.jevs.2020.103143

Ellwanger, J. H., Cardoso, J. da C., & Chies, J. A. B. (2021). Variability in human attractiveness to mosquitoes. *Current Research in Parasitology & Vector-Borne Diseases*, *1*, 100058. https://doi.org/10.1016/j.crpvbd.2021.100058

Flies, E. J., Lau, C. L., Carver, S., & Weinstein, P. (2018). Another Emerging Mosquito-Borne Disease? Endemic Ross River Virus Transmission in the Absence of Marsupial Reservoirs. *BioScience*, *68*(4), 288–293. https://doi.org/10.1093/biosci/biy011

Gatton, M. L., Kelly-Hope, L. A., Kay, B. H., & Ryan, P. A. (2004). Spatial-temporal analysis of Ross River virus disease patterns in Queensland, Australia. *The American Journal of Tropical Medicine and Hygiene*, *71*(5), 629–635. https://doi.org/10.4269/ajtmh.2004.71.629

Hime, N. J., Wickens, M., Doggett, S. L., Rahman, K., Toi, C., Webb, C., Vyas, A., & Lachireddy, K. (2022). Weather extremes associated with increased Ross River virus and Barmah Forest virus notifications in NSW: Learnings for public health response. *Australian and New Zealand Journal of Public Health*, *46*(6), 842–849. https://doi.org/10.1111/1753-6405.13283

Himeidan, Y. E., Elbashir, M. I., & Adam, I. (2004). Attractiveness of pregnant women to the malaria vector, Anopheles arabiensis, in Sudan. *Annals of Tropical Medicine & Parasitology*, *98*(6), 631-633.

Kelly-Hope, L. A., Purdie, D. M., & Kay, B. H. (2004). Ross River Virus Disease in Australia, 1886–1998, with Analysis of Risk Factors Associated with Outbreaks. *Journal of Medical Entomology*, *41*(2), 133–150. https://doi.org/10.1603/0022-2585-41.2.133

Koolhof, I. S., Firestone, S. M., Bettiol, S., Charleston, M., Gibney, K. B., Neville, P. J., Jardine, A., & Carver, S. (2021). Optimising predictive modelling of Ross River virus using meteorological variables. *PLOS Neglected Tropical Diseases*, *15*(3), e0009252. https://doi.org/10.1371/journal.pntd.0009252

Koolhof, I. S., Gibney, K. B., Bettiol, S., Charleston, M., Wiethoelter, A., Arnold, A.-L., Campbell, P. T., Neville, P. J., Aung, P., Shiga, T., Carver, S., & Firestone, S. M. (2020). The forecasting of dynamical Ross River virus outbreaks: Victoria, Australia. *Epidemics*, *30*, 100377. https://doi.org/10.1016/j.epidem.2019.100377

Lindsay, S., Ansell, J., Selman, C., Cox, V., Hamilton, K., & Walraven, G. (2000). Effect of pregnancy on exposure to malaria mosquitoes. *The Lancet*, *355*(9219), 1972.

Liu, Z., & He, X. (2024). Contrastive Preference-Guided Active Learning Approach Based on Ranking Correlation for Real-Time Safety Assessment. *IEEE Transactions on Automation Science and Engineering*, 1–12. Scopus. https://doi.org/10.1109/TASE.2024.3401470

McIver, L., Xiao, J., Lindsay, M. D. A., Rowe, T., & Yun, G. (2010). A climate-based early warning system to predict outbreaks of Ross River virus disease in the Broome region of Western Australia. *Australian and New Zealand Journal of Public Health*, *34*(1), 89–90. https://doi.org/10.1111/j.1753-6405.2010.00480.x

Msellemu, D., Tanner, M., Yadav, R., & Moore, S. J. (2024). Occupational exposure to malaria, leishmaniasis and arbovirus vectors in endemic regions: A systematic review. *Current Research in Parasitology & Vector-Borne Diseases*, *6*, 100185. https://doi.org/10.1016/j.crpvbd.2024.100185

Murphy, A. K., Clennon, J. A., Vazquez-Prokopec, G., Jansen, C. C., Frentiu, F. D., Hafner, L. M., Hu, W., & Devine, G. J. (2020). Spatial and temporal patterns of Ross River virus in south east Queensland, Australia: Identification of hot spots at the rural-urban interface. *BMC Infectious Diseases*, *20*(1), 722. https://doi.org/10.1186/s12879-020-05411-x

Qian, W., Viennet, E., Glass, K., & Harley, D. (2020). Epidemiological models for predicting Ross River virus in Australia: A systematic review. *PLOS Neglected Tropical Diseases*, *14*(9), e0008621. https://doi.org/10.1371/journal.pntd.0008621

Woodruff, R. E., Guest, C. S., Garner, M. G., Becker, N., & Lindsay, M. (2006). Early Warning of Ross River Virus Epidemics: Combining Surveillance Data on Climate and Mosquitoes. *Epidemiology*, *17*(5), 569. https://doi.org/10.1097/01.ede.0000229467.92742.7b

World Health Organisation (2020). WHO methods and data sources for global burden of disease estimates 2000-2019.

PROFILE 8: SECONDARY MENTAL INJURY AS A RESULT OF OCCUPATIONAL INJURY

Key insights

- Secondary mental injury is a psychological condition that develops following primary work-related physical injury or illness.
- Emerging evidence suggests that the prevalence of secondary mental injuries is increasing, with 30-50% of people meeting screening criteria for depression following a workplace injury.
- Secondary mental injury can be monitored through psychological reporting scales during their recovery from a physical injury, often conducted as part of risk screening practices.
- Studies have mentioned that perceived unfair claiming processes for physical injury have been found to contribute to secondary mental injury.
- Studies suggest that utilisation of mental health services tends to increase following occupational injury, with higher prevalence later in a claim when conditions begin to become chronic.
- When workplace injury happens, comprehensive rehabilitation approaches that integrate physical and psychological care need to be implemented.
- Effective workplace and claim management of a work-related injury is necessary to prevent secondary mental injury, including better communication between claimants, supervisors, colleagues, case managers, and health providers.

Overview of the issue

Secondary mental injury refers to psychological problems that develop following a primary physical work-related injury (WorkSafe Victoria, n.d.). Research suggests that 25-45% of workers develop symptoms of depression within a month of injury, with these symptoms potentially lasting 6-12 months and hindering return to work (Carnide et al., 2016). Additionally, workers with occupational injuries are 2.39 times more likely to develop trauma and stress-related disorders and 3.26 times more likely to suffer from substance dependence compared to those without such injuries (Chin et al., 2022).

Studies also show that occupational injury can lead to long-term psychological effects, with 3.2% of injured workers experiencing PTSD and 1.9% experiencing major depression after 12 months (Lin et al., 2014). In their meta-analysis, Granger and Turner (2024) found a bidirectional relationship between occupational injury and mental health, where work injuries can lead to mental health challenges, and mental health issues can increase the risk of injury. Cognitive factors such as negative thoughts and perceived job demands mediate this relationship (Granger & Turner, 2024). Therefore, current available evidence highlights the growing burden of secondary mental injury following a primary occupational injury.

Secondary mental injury following workers' compensation claims

Evidence suggested that the process of claiming for work-related injury increases the chance of developing secondary mental injury, especially when there is a perceived unfairness in the process (Orchard, Carnide, & Smith, 2020; Orchard et al., 2021). A study in Victoria, Australia revealed that negative perceptions of fairness during interactions between claim agents and claimants are correlated with poorer mental health outcomes among workers who are pursuing work-related physical injury claims (Orchard et al., 2020). These findings are further confirmed by another study conducted in Ontario, Canada, which discovered that low perceptions of informational justice were associated with 2.58 times higher risk of serious mental illness (Orchard et al., 2021).

Moreover, a review by Kilgour et al. (2015b) found that negative interactions between injured workers and insurers caused considerable psychosocial consequences among injured workers. In another study, Kilgour et al. (2015a) also found that healthcare providers can both help and hinder recovery among injured workers. Supportive patient-centred care was crucial in fostering recovery, while adversarial relationships and organisational pressures between providers and insurers negatively affect the therapeutic process. This is also confirmed by a cross-sectional survey by Collie et al. (2020) that discovered that workers who reported stressful interactions with healthcare provider(s) were 1.58 more likely to have psychological distress. Therefore, the evidence suggests that work claim processes that are perceived as unjust and unfair can further exacerbate secondary mental injury because of occupational injuries.

Monitoring of secondary mental injury

Evidence regarding the monitoring of secondary mental injury as a result of primary work-related injury is limited. However, Nwaogu et al. (2019), explored the possibility of using a self-psychological reporting scale following the worker's return to work after a physical injury. Studies recommend several ways to prevent secondary mental injury following physical occupational injuries. When a work-related injury happens, comprehensive rehabilitation approaches that integrate physical and psychological care need to be implemented (Granger & Turner, 2024). Additionally, during the workers' compensation claim process, the interactions between claimants, supervisors, colleagues, and case managers also need to be fairer and just according to the workers' perspectives (Orchard et al., 2021). Clear, open, and respectful communication with workers' compensation claimants is key in supporting timely recovery and facilitating their return to work (Orchard et al., 2021).

Conclusion

In conclusion, the evidence highlights a significant connection between work-related injuries and the subsequent development of secondary mental injuries, such as depression and PTSD. The prevalence of these mental health challenges is exacerbated by the claims process, particularly when perceived as unjust or unfair. To mitigate the risks of secondary mental injuries, it is essential for workplaces to implement comprehensive rehabilitation approaches that address both physical and psychological needs. By prioritising fair interactions during the claims process and promoting mental health support, organisations can enhance recovery outcomes and overall worker well-being. Moreover, improved fairness and transparency among insurers during the claim process is also essential to prevent exacerbation of secondary mental injury among injured workers. Better communication, education, and streamlined administrative procedures between injured workers and health providers are also needed to avoid worsening of psychological conditions of injured workers.

References

Carnide, N., Franche, R.-L., Hogg-Johnson, S., Côté, P., Breslin, F. C., Severin, C. N., Bültmann, U., & Krause, N. (2016). Course of Depressive Symptoms Following a Workplace Injury: A 12-Month Follow-Up Update. *Journal of Occupational Rehabilitation*, *26*(2), 204–215. https://doi.org/10.1007/s10926-015-9604-3

Chin, W.-S., Liao, S.-C., Pan, S.-C., & Guo, Y.-L. L. (2022). Occupational and Non-occupational Injuries Can Result in Prolonged Augmentation of Psychiatric Disorders. *Journal of Epidemiology*, *32*(1), 12–20. https://doi.org/10.2188/jea.JE20200374

Collie, A., Sheehan, L., Lane, T. J., & Iles, R. (2020). Psychological Distress in Workers' Compensation Claimants: Prevalence, Predictors and Mental Health Service Use. *Journal of Occupational Rehabilitation*, *30*(2), 194–202. https://doi.org/10.1007/s10926-019-09862-1

Granger, S., & Turner, N. (2024). Work injuries and mental health challenges: A meta-analysis of the bidirectional relationship. *Personnel Psychology*, *n/a*(n/a). https://doi.org/10.1111/peps.12649

Kilgour, E., Kosny, A., McKenzie, D., & Collie, A. (2015a). Healing or Harming? Healthcare Provider Interactions with Injured Workers and Insurers in Workers' Compensation Systems. *Journal of Occupational Rehabilitation*, *25*(1), 220–239. https://doi.org/10.1007/s10926-014-9521-x

Kilgour, E., Kosny, A., McKenzie, D., & Collie, A. (2015b). Interactions Between Injured Workers and Insurers in Workers' Compensation Systems: A Systematic Review of Qualitative Research Literature. *Journal of Occupational Rehabilitation*, *25*(1), 160–181. https://doi.org/10.1007/s10926-014-9513-x

Lin, K.-H., Shiao, J. S.-C., Guo, N.-W., Liao, S.-C., Kuo, C.-Y., Hu, P.-Y., Hsu, J.-H., Hwang, Y.-H., & Guo, Y. L. (2014). Long-Term Psychological Outcome of Workers After Occupational Injury: Prevalence and Risk Factors. *Journal of Occupational Rehabilitation*, *24*(1), 1–10. https://doi.org/10.1007/s10926-013-9431-3

Nwaogu, J. M., Chan, A. P. C., Hon, C. K. H., & Darko, A. (2019). Review of global mental health research in the construction industry: A science mapping approach. *Engineering, Construction and Architectural Management*, *27*(2), 385–410. https://doi.org/10.1108/ECAM-02-2019-0114

Orchard, C., Carnide, N., & Smith, P. (2020). How Does Perceived Fairness in the Workers' Compensation Claims Process Affect Mental Health Following a Workplace Injury? *Journal of Occupational Rehabilitation*, *30*(1), 40–48. https://doi.org/10.1007/s10926-019-09844-3

Orchard, C., Carnide, N., Smith, P., & Mustard, C. (2021). The Association Between Case Manager Interactions and Serious Mental Illness Following a Physical Workplace Injury or Illness: A Cross-Sectional Analysis of Workers' Compensation Claimants in Ontario.

Journal of Occupational Rehabilitation, *31*(4), 895–902. https://doi.org/10.1007/s10926-021-09974-7

PROFILE 9: SILICOSIS OUTSIDE OF CONSTRUCTION, MANUFACTURING AND MINING

Key insights

- Silicosis, a preventable occupational lung disease caused by inhaling respirable crystalline silica (RCS) dust, remains a persistent issue, particularly in industries like mining, construction, engineered stone fabrication, and newer industries such as denim manufacturing and artistic fields like sculpting and jewellery making.
- There has been a resurgence of silicosis, especially among younger workers in the engineered stone sector. Recent epidemiological data from Australia indicates a rise in silicosis cases, growing from approximately 350 in 2019 to over 500 by 2022.
- Emerging technologies, such as portable real-time RCS dust monitors and AI-enabled radiology tools, are being explored for the early detection and monitoring of silicosis.
- Advances in diagnostic methods, such as high-resolution computed tomography (HRCT) and biomarkers in exhaled breath condensate (EBC), show promise for detecting early-stage silicosis.
- The 2024 ban on the use, supply, and manufacture of engineered stone, along with the establishment of the National Occupational Respiratory Disease Registry in Australia, are significant developments in reducing and managing the risk of silicosis.
- Ongoing collaboration between industry stakeholders, government agencies, and public health organisations is vital for protecting workers and preventing the devastating effects of silicosis.

Overview of the issue

Silicosis, caused by inhaling respirable crystalline silica (RCS) dust, is a preventable but persistent occupational health issue. Despite extensive regulatory measures and heightened awareness, it continues to affect industries such as mining, construction, and engineered stone fabrication, where workers are exposed to hazardous levels of silica dust (Austin, 2021; Casey, 2019). This ongoing problem highlights the challenge of fully safeguarding workers from silica exposure (Hoy et al., 2020; Gandhi, 2023).

Historically, workers in high-risk industries like mining and stonemasonry have been recognised as particularly vulnerable due to frequent silica dust exposure (Hoy et al., 2020; Casey, 2019). The rise of newer industries, especially those involving cutting, grinding, and polishing engineered stone, has worsened the situation (Sanchez-Morillo, 2024; Gandhi, 2023). Additionally, smaller industries, such as denim manufacturing and various artistic fields (e.g. sculpting, jewellery making, etc.), also present risks due to insufficient safety measures and awareness (Austin, 2021; Cole, 2023).

Recent epidemiological data show a significant rise in silicosis cases, particularly among younger workers in the engineered stone sector. In Australia, cases increased from approximately 350 in 2019 to over 500 by May 2022, predominantly within the stone benchtop industry (Austin, 2021; Hoy et al., 2022). This rise, driven by exposure to high-silica-content materials, has been recognised as a public health crisis (Cole, 2023). Similar trends have been observed globally, with outbreaks in countries such as Israel, Spain, and the USA linked to artificial stone use (Hoy et al., 2020; Gandhi, 2023).

Monitoring and surveillance

The inconsistent application of air quality monitoring and real-time dust exposure assessments continues to challenge worker protection (Cole, 2023; Noi, 2024). A survey of occupational hygienists in Australia found that about 20% reported inadequate air quality assessments in high-risk industries (Cole, 2023). While larger industries, like mining, may comply better with safety standards, smaller businesses often lack the resources to implement protective measures fully, increasing worker risk (Cole, 2023).

Addressing silicosis requires a combination of regulatory enforcement and workplace interventions. The National Institute for Occupational Safety and Health (NIOSH) advocates for the hierarchy of controls, prioritising the elimination of hazardous materials as the most effective risk-reduction strategy, with engineering controls and personal protective equipment (PPE) as secondary measures (Gandhi, 2023). In Australia, discussions about banning engineered stone to reduce silica exposure began in 2023, with safer alternatives like natural stone being considered. As a result, on 1 July 2024, Australia became the first country in the world to implement a complete ban on the use, supply, and manufacture of engineered stone (Gandhi, 2023; Department of Employment and Workplace Relations, 2024).

Public health initiatives play a crucial role in early silicosis detection. Programs such as California's "sentinel" case identification system and Queensland's worker health screening and compensation scheme are vital in this effort (Gandhi, 2023). Additionally, health insurance claims data, including Medicare records, are effective tools for tracking silicosis prevalence and incidence, providing valuable insights into the disease's long-term impacts (Casey, 2019). The establishment of the Australian National Occupational Respiratory Disease Registry in May 2024 is also a key development, centralising data on respiratory diseases and enhancing monitoring, prevention, and regulatory responses (Department of Health and Aged Care, 2024).

Advances in diagnostic technology are providing new opportunities for early detection of silicosis (**note:** most of these methods are not industry-specific and may therefore be broadly applicable across various occupational settings). Traditional methods, such as chest X-rays, often fail to detect early-stage silicosis, allowing the disease to progress unnoticed until it becomes severe (Hoy et al., 2020; Li, 2022). While high-resolution computed tomography (HRCT) provides a more reliable alternative, its use is limited by high costs and radiation exposure (Austin, 2021; Li, 2022). Emerging technologies like portable real-time RCS monitoring devices offer promise, though they are challenged by accuracy issues related to environmental factors (Noi, 2024). Additionally, innovative tools, such as AI-enabled radiology and biomarkers in exhaled breath condensate (EBC), are under investigation for their potential to revolutionise early detection (Li, 2022; Austin, 2021).

Furthermore, combining routine blood tests with machine learning algorithms is being explored to enhance early detection and monitoring of silicosis. Biomarkers like lactate dehydrogenase (LDH), angiotensin-converting enzyme (ACE), and fibrinogen have shown promise in distinguishing healthy individuals from those at different stages of the disease (Sanchez-Morillo, 2024). These methods could provide a more accessible and cost-effective approach to early diagnosis, particularly for workers in high-risk industries.

Conclusion

Silicosis remains a major occupational health concern, exacerbated by the rise of industries exposing workers to RCS dust. Although advancements in real-time monitoring and early detection tools offer hope, substantial work is still needed to reduce the incidence of this preventable disease. Continued collaboration among industry stakeholders, government agencies, and public health organisations is essential to protecting workers and mitigating the severe effects of silicosis.

References

Austin, E. K., James, C., & Tessier, J. (2021). Early Detection Methods for Silicosis in Australia and Internationally: A Review of the Literature. *International Journal of Environmental Research and Public Health*, *18*(15), Article 15. https://doi.org/10.3390/ijerph18158123

Casey, M. L., & Mazurek, J. M. (2019). Silicosis prevalence and incidence among Medicare beneficiaries. *American Journal of Industrial Medicine*, *62*(3), 183–191. https://doi.org/10.1002/ajim.22944

Cole, K., Glass, D., Bence, T., Pisaniello, D., Knott, P., Rowett, S., & Johnson, S. (2023). Prevention of the Occupational Silicosis Epidemic in Australia: What Do Those Who Assess Workplace Health Risk Think Should Be Done Now? *Annals of Work Exposures and Health*, *67*(2), 281–287. https://doi.org/10.1093/annweh/wxac064

Department of Employment and Workplace Relations. (2024). Prohibition on the use of engineered stone. Australian Government Department of Employment and Workplace Relations. https://www.dewr.gov.au/engineeredstone

Department of Health and Aged Care. (2024). About the National Occupational Respiratory Disease Registry. Australian Government Department of Health and Aged Care. https://www.health.gov.au/our-work/nordr/about

Gandhi, S. A., Heinzerling, A., Flattery, J., Fazio, J. C., Alam, A., Cummings, K. J., & Harrison, R. J. (2023). Active Surveillance of Engineered Stone Workers Facilitates Early Identification of Silicosis: A Discussion of Surveillance of Occupational Lung Diseases. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, *33*(2–3), 119–129. https://doi.org/10.1177/10482911231189503

Hoy, R. F., & Chambers, D. C. (2020). Silica-related diseases in the modern world. *Allergy*, *75*(11), 2805–2817. https://doi.org/10.1111/all.14202

Hoy, R. F., & Sim, M. R. (2022). Correspondence on 'Demographic, exposure and clinical characteristics in a multinational registry of engineered stone workers with silicosis' by Hua *et al*. *Occupational and Environmental Medicine*, *79*(9), 647–648. https://doi.org/10.1136/oemed-2022-108496

Li, T., Yang, X., Xu, H., & Liu, H. (2022). Early Identification, Accurate Diagnosis, and Treatment of Silicosis. *Canadian Respiratory Journal*, *2022*(1), 3769134. https://doi.org/10.1155/2022/3769134

Noi, D. D. T., Davies, B., & Gopaldasani, V. (2024). End-of-Shift Monitoring of Respirable Crystalline Silica: A Critical Review of Measurement Techniques and Factors Influencing Accurate Measurements. *Critical Reviews in Analytical Chemistry*, *54*(6), 1492–1501. https://doi.org/10.1080/10408347.2022.2117979

Sanchez-Morillo, D., León-Jiménez, A., Guerrero-Chanivet, M., Jiménez-Gómez, G., Hidalgo-Molina, A., & Campos-Caro, A. (2024). Integrating routine blood biomarkers and artificial intelligence for supporting diagnosis of silicosis in engineered stone workers. *Bioengineering & Translational Medicine*, *n/a*(n/a), e10694. https://doi.org/10.1002/btm2.10694

PROFILE 10: WORK-RELATED CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD)

Key Insights

- Chronic Obstructive Pulmonary Disease (COPD) is a chronic respiratory condition that develops from prolonged exposure to inhalable inflammatory substances such as tobacco, fumes, dust, and many more.
- COPD is one of the leading causes of death worldwide (fifth in Australia) with rates of 42 deaths per 100,000 people. It is caused by prolonged exposure to inflammatory substances such as vapour, gas, dusts, and fumes.
- COPD is a highly preventable disease by reducing exposure to risk factors or using personal protective equipment such as gas masks and respirators, as well as conducting surveillance methods to identify high-risk workers and give them early interventions.
- Surveillance can be done by symptom tracking, lung function testing, as well as utilising AI technologies to identify, classify, and make decisions about work-related COPD.

Overview of the issue

Chronic Obstructive Pulmonary Disease (COPD) is a respiratory condition that stems from a prolonged exposure of the lungs to inflammatory substances such as tobacco, air pollution, dust, and many other inhalable substances (WHO, 2023). These respirable substances cause swelling and irritation of the airway over time, which results in the obstructed airflow into and out of the lungs (WHO, 2023). Moreover, COPD can be caused by predisposing genetic factors or other chronic conditions such as asthma or severe respiratory infections in childhood (Silverman, 2020). COPD typically develops in adulthood and can be derived from two main conditions, namely emphysema, which refers to destruction of air sacs in the lungs, or chronic bronchitis, which refers to a chronic cough with production of phlegm (Blanc et al., 2019). Therefore, people with COPD often experience symptoms such as wheezing, difficulty breathing and chronic cough with mucus (WHO, 2023). Prolonged development of COPD can be life-threatening, with the condition ranked fourth among the global leading causes of death in 2021, with rates of 42 deaths per 100,000 people (De Matteis, 2022; WHO, 2021). However, COPD is also highly preventable when exposure to risk factors can be limited (Minov, 2022).

Studies suggest that work-related COPD risk factors are burdensome but also one of the most preventable causes after tobacco smoking (De Matteis, 2022). Carcinogen Exposure (CAREX) database showed that in Canada, there were 386,000 deaths in 2000 due to chronic non-malignant respiratory diseases and approximately 6.6 million disability-adjusted life years (DALYs) due to work exposure to airborne particulates, especially because of COPD (Minov, 2022). Furthermore, occupational exposures to vapours, dusts, gases, and fumes continue to be important risk factors for COPD development (Getahun et al., 2021). Recent studies indicate that the prevalence of COPD among U.S. workers increased by 1.5% annually from 2012 to 2018, with 27.3% of cases attributable to occupational exposures (Syamlal et al., 2021). Moreover, emerging trends include the rise of cleaning-related respiratory diseases due to the growth of service and healthcare sectors (Fazen et al., 2020). Recent research has identified new potential occupational causes of COPD, including pesticides and cleaning products, particularly disinfectants (De Matteis, 2022).

In Australia, COPD remains a significant health burden, affecting approximately 1 in 13 people over 40 years old and is the fifth leading cause of death (Dabscheck et al., 2022; Ivey et al., 2024). While smoking is the primary risk factor, occupational exposures contribute substantially to COPD development, accounting for 14% of cases (Murgia & Gambelunghe, 2022). Industries that are related to an increased COPD risk include mining, manufacturing, agriculture, construction, metals, and textile factories (De Matteis, 2022). To reduce the burden of COPD, in environments where exposure to respiratory sensitisers and irritants are high and continuous, it is essential to implement the primary prevention measures. These include, but are not limited to, minimising exposure to respiratory sensitisers and irritants, predicting new sensitisers or irritants before they are used, as well as using personal protective equipment such as facial masks or respirators (Minov, 2022).

Monitoring and surveillance

Traditionally, effective surveillance methods for occupational COPD include a combination of respiratory questionnaires, lung function measurements, and exposure control in the workplace (Fishwick et al., 2015). A prediction model based on symptoms, smoking history, and work-related factors can help identify high-risk workers (Meijer et al., 2001). Annual lung function testing is important for detecting workers with rapidly declining lung function (Fishwick et al., 2015). Improved interpretation of lung function tests, including the use of lower limits of normal values and longitudinal data analysis, is recommended (Lewis & Fishwick, 2013). Additionally, immunological tests may be useful for workers exposed to common occupational allergens (Lewis & Fishwick, 2013).

Recently, Artificial Intelligence (AI) is increasingly being applied to manage COPD as a complex respiratory condition. AI techniques, particularly neural networks, support vector machines, and decision trees, are being used for COPD identification, classification, and prevention, with performance metrics generally between 80-90% (De Ramón Fernández et al., 2021). These AI models show promise as complementary tools for clinical decision-making in COPD management (De Ramón Fernández et al., 2021; San José Estépar, 2021). AI applications in COPD research have accelerated recently, focusing on diagnosis, prognosis, patient classification, and disease management (Exarchos et al., 2022). Specific AI applications include screening for COPD using low-dose CT scans (Bibault & Xing, 2020). While AI shows great potential in COPD research and management, more high-quality studies are needed to validate these findings and address challenges in implementing AI in clinical practice (De Ramón Fernández et al., 2021; Exarchos et al., 2022).

Conclusion

In conclusion, work-related COPD remains a growing concern both in Australia and worldwide due to its high morbidity (De Matteis, 2022; Ivey et al., 2024). Early detection and primary prevention measures are needed to reduce the risk of COPD development among workers, especially in industries that require a high and prolonged exposure to respiratory sensitisers and irritants (Minov, 2022). Several methods have been implemented to conduct surveillance for occupational COPD, including the traditional symptom tracking and lung function measurement, as well as the more recent AI utilisation for diagnosis and clinical decision-making (De Ramón Fernández et al., 2021; Exarchos et al., 2022; Fishwick et al., 2015). These measures are crucial for preventing further lung function decline and reducing the health and socioeconomic burden of COPD (Murgia & Gambelunghe, 2022).

References

Bibault, J.-E., & Xing, L. (2020). Screening for chronic obstructive pulmonary disease with artificial intelligence. *The Lancet Digital Health*, *2*(5), e216–e217. https://doi.org/10.1016/s2589-7500(20)30076-5

Blanc, P. D., Annesi-Maesano, I., Balmes, J. R., Cummings, K. J., Fishwick, D., Miedinger, D., Murgia, N., Naidoo, R. N., Reynolds, C. J., Sigsgaard, T., Torén, K., Vinnikov, D., & Redlich, C. A. (2019). The Occupational Burden of Nonmalignant Respiratory Diseases. An Official American Thoracic Society and European Respiratory Society Statement. *American Journal of Respiratory and Critical Care Medicine*, *199*(11), 1312–1334. https://doi.org/10.1164/rccm.201904-0717ST

Dabscheck, E., George, J., Hermann, K., McDonald, C. F., McDonald, V. M., McNamara, R., O'Brien, M., Smith, B., Zwar, N. A., & Yang, I. A. (2022). COPD-X Australian guidelines for the diagnosis and management of chronic obstructive pulmonary disease: 2022 update. *Medical Journal of Australia*, *217*(8), 415–423. https://doi.org/10.5694/mja2.51708

De Matteis, S. (2022). Occupational causes of chronic obstructive pulmonary disease: An update. *Current Opinion in Allergy and Clinical Immunology*, *22*(2), 73–79. https://doi.org/10.1097/ACI.0000000000000817

De Ramón Fernández, A., Ruiz Fernández, D., Gilart Iglesias, V., & Marcos Jorquera, D. (2021). Analyzing the use of artificial intelligence for the management of chronic obstructive pulmonary disease (COPD). *International Journal of Medical Informatics*, *158*, 104640. https://doi.org/10.1016/j.ijmedinf.2021.104640

Exarchos, K., Aggelopoulou, A., Oikonomou, A., Biniskou, T., Beli, V., Antoniadou, E., & Kostikas, K. (2022). Review of Artificial Intelligence Techniques in Chronic Obstructive Lung Disease. *IEEE Journal of Biomedical and Health Informatics*, *26*(5), 2331–2338. https://doi.org/10.1109/jbhi.2021.3135838

Fazen, L. E., Linde, B., & Redlich, C. A. (2020). Occupational lung diseases in the 21st century: The changing landscape and future challenges. *Curr. Opin. Pulm. Med.*, *26*(2), 142–148. https://doi.org/10.1097/MCP.0000000000000658

Fishwick, D., Sen, D., Barber, C., Bradshaw, L., Robinson, E., Sumner, J., & The COPD Standard Collaboration Group. (2015). Occupational chronic obstructive pulmonary disease: A standard of care. *Occupational Medicine*, *65*(4), 270–282. https://doi.org/10.1093/occmed/kqv019

Getahun, B., Bekel, A. A., Getahun, B., & Bekel, A. A. (2021). Work—Related Chronic Obstructive Pulmonary Disease. In *Chronic Obstructive Pulmonary Disease—A Current Conspectus*. IntechOpen. https://doi.org/10.5772/intechopen.96131

Ivey, M. A., Smith, S. M., Benke, G., Toelle, B. G., Hunter, M. L., James, A. L., Maguire, G. P., Wood-Baker, R., Johns, D. P., Marks, G. B., & Abramson, M. J. (2024). COPD in

Never-Smokers: BOLD Australia Study. *International Journal of Chronic Obstructive Pulmonary Disease*, *19*, 161–174. https://doi.org/10.2147/COPD.S439307

Lewis, L., & Fishwick, D. (2013). Health surveillance for occupational respiratory disease. *Occupational Medicine*, *63*(5), 322–334. https://doi.org/10.1093/occmed/kqt048

Meijer, E., Grobbee, D. E., & Heederik, D. J. (2001). Health surveillance for occupational chronic obstructive pulmonary disease. *Journal of Occupational and Environmental Medicine*, *43*(5), 444–450. https://doi.org/10.1097/00043764-200105000-00003

Minov, J. (2022). Occupational chronic obstructive pulmonary disorder: Prevalence and prevention. *Expert Review of Respiratory Medicine*, *16*(4), 429–436. https://doi.org/10.1080/17476348.2021.2011722

Murgia, N., & Gambelunghe, A. (2022). Occupational COPD—The most under-recognized occupational lung disease? *Respirology*, *27*(6), 399–410. https://doi.org/10.1111/resp.14272

San José Estépar, R. (2021). Artificial Intelligence in COPD: New Venues to Study a Complex Disease. *Barcelona Respiratory Network*, *6*(2). https://doi.org/10.23866/brnrev:2019-0014

Silverman, E. K. (2020). *Genetics of COPD | Annual Reviews*. https://www.annualreviews.org/content/journals/10.1146/annurev-physiol-021317-121224

Syamlal, G., Doney, B., Hendricks, S., & Mazurek, J. M. (2021). Chronic Obstructive Pulmonary Disease and U.S. Workers: Prevalence, Trends, and Attributable Cases Associated With Work. *American Journal of Preventive Medicine*, *61*(3), e127–e137. https://doi.org/10.1016/j.amepre.2021.04.011

WHO. (2021). *The top 10 causes of death*. https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death

WHO. (2023). *Chronic obstructive pulmonary disease (COPD)*. https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd)

Rapid Review

Background

Based on the RFS, Monash University worked with WorkSafe Victoria to develop the parameters of a rapid review designed to provide an in-depth exploration of a questions within the wider remit of the project. The original question identified was:

> **RQ1. What are the methods currently being used to undertake surveillance or monitoring of emerging or re-emerging occupational illnesses and diseases?**

However, after undertaking duplicate screening at the title and abstract stage of the project, it was clear that this broad question would not be feasible within the scope of the project. Therefore, the Monash University team suggested a revised question and bespoke method to undertake a review responding to the question:

> **RQ2. How are big data and artificial intelligence being used to better undertake surveillance and monitoring for zoonotic diseases in occupational settings?**

Methods

Search strategy

A detailed search strategy was developed with a specialist librarian and in collaboration with content matter experts from Monash University's Healthy Working Lives (HWL) Group. The most suitable databases to search from Monash University's extensive suite of subscribed academic content were determined. Through naïve searching and a request to WorkSafe Victoria (WSV), the research team identified key examples of high-quality papers for inclusion in the review; a 'gold set' group of papers that can act as an indicator of an effective search strategy.

Screening

Search results were imported into Covidence, a web-based software for managing systematic reviews. After record de-duplication two members of the review team screened the titles and abstracts of the remaining records for eligibility in duplicate against the inclusion and exclusion criteria (see Appendix 4). Any disagreements between the two screeners were resolved by either consensus, or adjudicated by a third screener. Due to the broad scope of initial review question, the first title and abstract screening process resulted in a yield of 568 articles (including seven duplicates). Such a large yield was assessed to be likely to result in a review that would require time and human resources outside of the scope of this project. Based on this, the Monash team designed a proposed approach to refining the review question by capitalising on data that could be drawn from the title and abstract screening process that had already been undertaken. WorkSafe Victoria approved of this revised approach in a regular project check in meeting. The revised approach is described below.

Question refinement through bibliographic analysis

The research team conducted a keyword co-occurrence analysis using VOSviewer, a freely available tool developed for the construction and visualisation of bibliometric maps (van Eck, 2010), to identify patterns in the 568 potentially relevant papers and scope a revised and refined review question. The analysis was based on a dataset containing 240 keywords, with a minimum co-occurrence frequency of three.

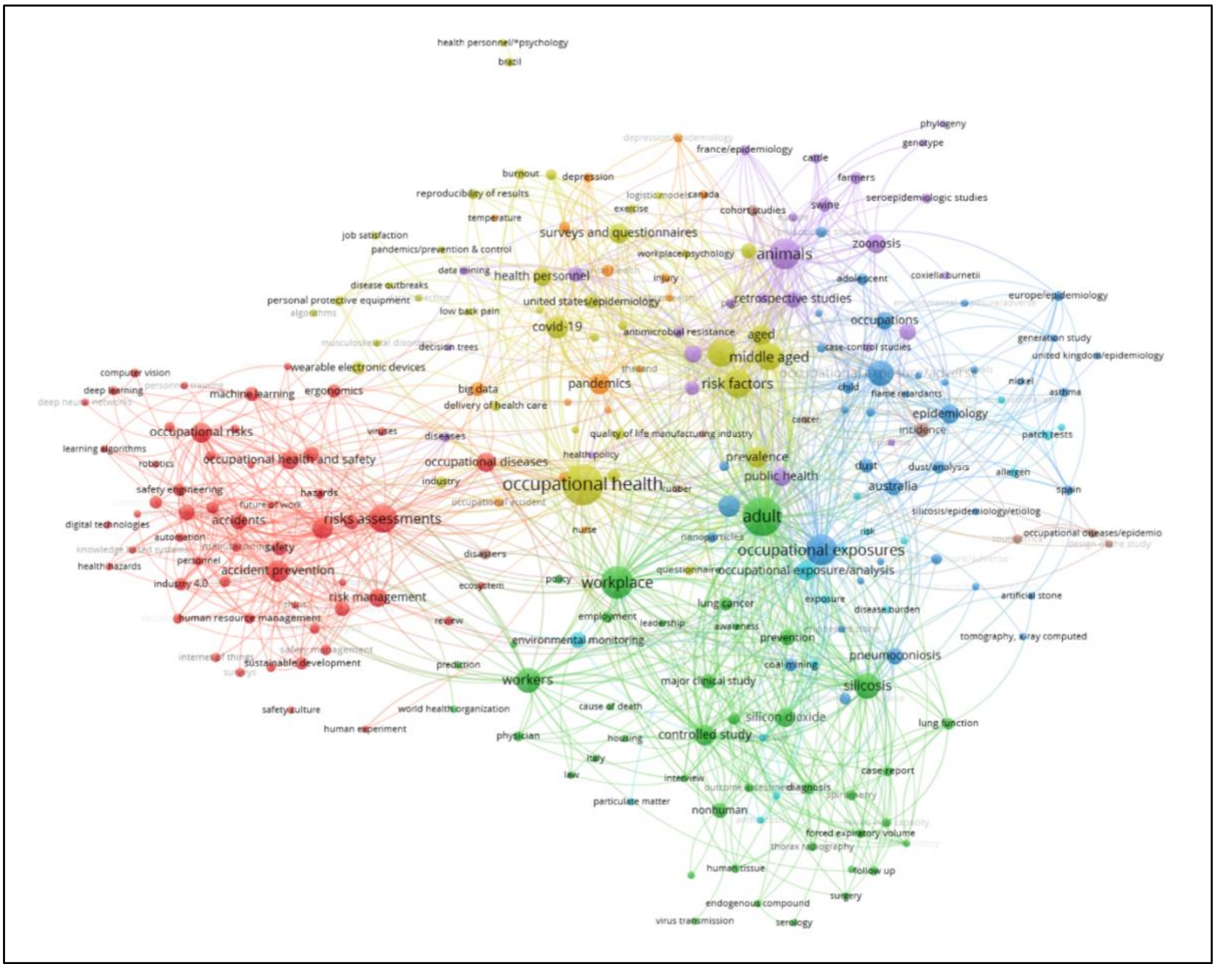

Fig 1. Keyword co-occurrence map of all 240 keywords (minimum co-occurrence frequency of 3 keywords)

The initial map (Fig 1) was generated to visualise keyword clusters. The analysis specifically targeted keywords associated with illnesses and diseases, excluding more general terms like "injury". Based on the RFS and commissioning conversations with WorkSafe Victoria, special attention was given to identifying keywords linked to monitoring, surveillance, and data linkage within the network. This resulted in two potential areas of focus.

1. To focus on how big data is being used to monitor zoonoses. When looking for keywords linked to big data, the map showed a co-occurrence with terms such as “animals” and “agriculture” (Fig 2). These terms were part of the purple cluster that was focused on zoonoses.

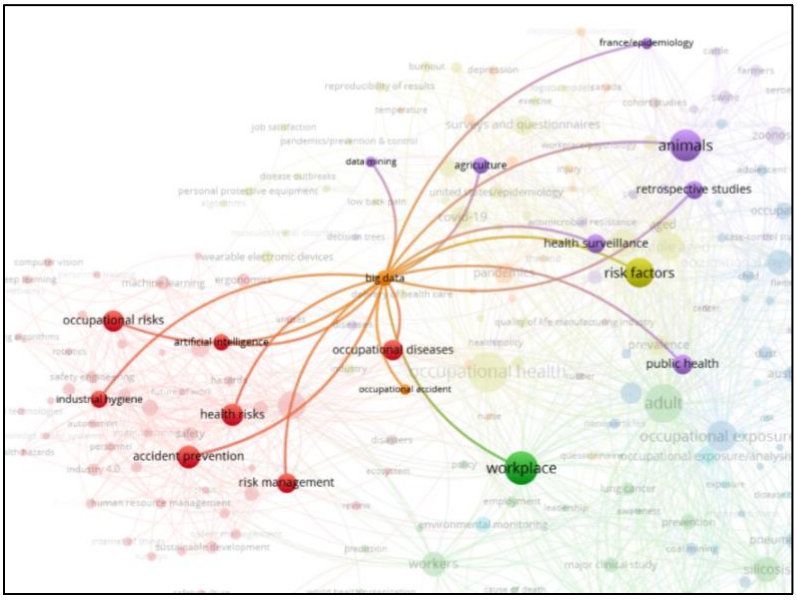

Fig 2. Keyword co-occurrence map highlighting keywords linked to big data.

2. To focus on a group of occupational illnesses and diseases and look at what surveillance/monitoring strategies they use. Focusing on the green cluster, which has keywords related to respiratory diseases such as silicosis, seemed to be promising as it also included multiple surveillance and monitoring keywords such as forced expiratory volume, thorax radiography, etc (see Fig 3). However, upon further analysis it seemed that proceeding with this option may a) still not be sufficiently refined, and b) require to high of a degree of specialist knowledge about the relative benefits of novel medical diagnostic tools and procedures.

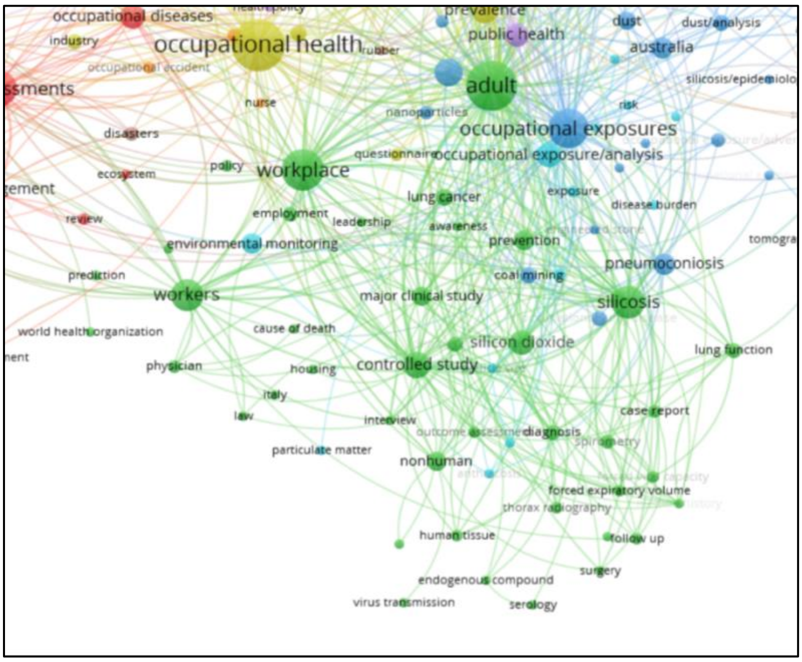

Fig 3. Keyword co-occurrence map of the respiratory disease (green) cluster

As a result, and after further consultation with content matter experts from the HWL team and discussions with WSV, the research team decided to go with the first option to answer the question: **How are big data and artificial intelligence being used to better undertake surveillance and monitoring for zoonotic diseases in occupational settings?**

Study selection and data extraction

Upon agreement of the refined research question, the list of articles in the full-text yield were imported into a new Covidence file and a second round of title and abstract screening was conducted in duplicate against a new set of eligibility criteria (see Appendix 4). Any disagreements between the two screeners were resolved by either consensus, or adjudicated by a third screener. The full text of articles that made it through to the next stage of screening were then retrieved and assessed in duplicate against the inclusion and exclusion criteria. Again, disagreements between screeners were resolved either via consensus or a third screener. See the PRISMA diagram in Appendix 5 for a summary of the study selection process.

Data extraction was then undertaken by one reviewer. The agreed items for extraction included:

- Author / Year / First author country
- Study aim
- Occupational setting
- Zoonotic disease type
- Source of data / Occupational health databases used (if any)
- Brief description of surveillance/monitoring method
- Author-stated key findings (in relation to RQ)
- Author-stated study limitations (in relation to RQ)
- Author-stated research opportunities (in relation to RQ)
- Author-stated conclusions (in relation to RQ)

After data extraction was completed, another reviewer cross-checked all of the articles to ensure extraction accuracy.

BRIEF NARRATIVE ABOUT KEY FINDINGS

Three reviews and 6 primary studies were identified in the screening process for inclusion. They focused on such a wide range of zoonotic illnesses that they are not enumerated here. The documents also frequently contained a clear link to occupational settings, but were not explicitly focused on surveillance in occupational settings. Thus, this is also not enumerated.

Given the nature of the review question, the information is presented in a narrative synthesis that provides some overarching comments derived from two of the included reviews (Boffetta & Collatuzzo, 2022; Gupta et al., 2024) and then discusses the other findings within a framework presented by one of the reviews (Boffetta & Collatuzzo, 2022).

There are a range of professions that are of high risk for zoonotic diseases, including veterinary professionals, butchers, animal owners and handlers, livestock and poultry workers, workers in food processing industries, sewage workers, hospital staff, and zoo workers (Gupta et al., 2024). Factors such as changes in demographics, globalisation, deforestation, and increasing frequency of travel contribute to the emergence of zoonotic diseases (Gupta et al., 2024). Addressing these challenges requires coordinated strategies, enhanced surveillance and improved management of human-animal-environment interactions (Gupta et al., 2024). Collaboration between several sectors (e.g. public health, veterinary, agricultural, etc) is critical to undertaking effective surveillance (Gupta et al., 2024). Using socio-demographic, biological, and genetic data, among others, AI is an emerging tool to diagnose, manage, prevent, and make decisions about various occupational diseases (Boffetta & Collatuzzo, 2022), including zoonoses that occur in occupational settings. Indeed, several use cases have been mentioned in two recent relevant reviews:

- Big data can be used to screen, track, and trace infections, this can include processing real-time data such as camera footage, facial recognition, bank card records, and Global Positioning System (GPS) data for monitoring potential contacts between infected people. (Boffetta & Collatuzzo, 2022).

- Geographic Information System (GIS) and maps can be used to monitor, track and map vector-borne and water-borne diseases, as well as trace the spread of infections (Boffetta & Collatuzzo, 2022; Gupta et al., 2024).
- Large ecological data sets can be used for analysis of site characteristics like soil type, water sources, and geology. These can help predict vector-borne diseases and epidemics (Gupta et al., 2024).
- GPS data and machine learning have both been mentioned as holding potential for forecasting global or regional transmission dynamics, as well as providing evidence to support monitoring and control programs in particular occupational settings (Boffetta & Collatuzzo, 2022; Gupta et al., 2024).
- Monitoring and control efforts for malaria, Zika, and dengue have been undertaken using algorithms generated by learning systems and AI (Boffetta & Collatuzzo, 2022, pg. 5).

Boffetta & Collatuzzo's (2022) review aimed to understand the potential applications of the P4 (Predictive, Preventive, Personalised, Participatory) Approach to occupational medicine.

After reviewing the included documents, it was clear that the P4 framework would be useful for organising the findings of the included studies, therefore, the findings are organised around four themes:

- Better prediction using machine learning.
- Better prevention using machine learning and big data.
- Personalisation of surveillance and monitoring approaches.
- Participatory approaches can enhance the quality of surveillance and the data on which it is based.

Better prediction using machine learning

In terms of prediction, Boffetta & Collatuzzo (2022) put forward that a range of forms of individual data such as genetic testing, family and medical history, work history, lifestyle and general health information can be stratified by occupation, working load, working activities, and occupational exposure to create large job specific datasets. These datasets can then be integrated through machine learning to predict risk factor and diagnose health problems (Boffetta & Collatuzzo, 2022).

The review did not identify cases in which large amounts of individual worker data were compiled and processed in the manner described above. It did, however, identify a study where a pre-existing data set was used to determine which machine learning model would perform best for predicting risks for zoonotic diseases that are applicable to occupational settings.

Kader et al. (2021) undertook a study to predict and forecast emerging poultry diseases (e.g. avian influenza, Newcastle disease) using machine learning algorithms. They tested eleven different machine learning models based on a pre-existing dataset of 500 birds with 30 characteristics each. The study authors found that the Random Forest Classifier was the most accurate model using these data, with 97% accuracy demonstrated in this study. The worst performing model had 74% accuracy (k-nearest neighbour classifier). Overall, the study demonstrated that several machine learning models and data mining algorithms likely hold value for predicting and preventing emerging diseases in the poultry industry (Kader et al., 2021). This study has direct application to individuals working in the poultry industry, as well as in some agricultural settings.

Better prevention with machine learning and big data

In terms of prevention, the identification of risk factors from genetic to exposure to harmful substances can be detected through machine learning to prevent occupational-related malignancy (Clark et al., 2020; Boffetta & Collatuzzo, 2022). The data can also be used to screen high-risk individuals and design primary interventions.

Three studies used machine learning in ways that may better inform how to prioritise surveillance and monitoring efforts to identify emerging and re-emerging illnesses and diseases.

Majewska et al. (2021) used a machine learning technique called the Boosted Regression Trees (BRT) model to examine which characteristics of helminths may be the best indicators of their potential to cause disease in humans. The model predicted zoonotic and non-zoonotic species with 91% accuracy, finding that transmission characteristics (like their definitive and intermediate hosts) and geography (e.g. where they are distributed) to be the most important indicators for understanding the helminths potential for infecting humans. Studies like this can be used to identify and prioritise the monitoring of species that have previously not been considered a risk for transmission within humans. Through such predictions, key locations and organisms that put workers at risk for exposure to potentially emerging diseases from helminths may be identified and monitored.

Another study looked at the potential value of pooling a range of surveillance data to provide greater insights into long term disease dynamics. Yon et al. (2029) sought to provide an update on changes in the epidemiology of several infectious wildlife-related diseases in Europe from 2010-2016, highlighting their past or potential future impacts on the health of humans, livestock, and wildlife (Yon et al., 2019). It combined data from many observations from passive surveillance programs (~18,000 annual observations) and more than 50,000 observations from active surveillance programs about a range of diseases (including bat lyssavirus infections, Q Fever, Crimean-Congo haemorrhagic fever, Echinococcosis (hydatid disease), Hantaviruses, Hepatitis E, Filovirus infection, Tularaemia, Leishmaniasis, rabies, Salmonella, West Nile virus). The surveillance data and literature review showed that the epidemiologic changes in the selected list of zoonotic diseases was typically due to an increase in the number of susceptible host species, an expansion of their geographic range, or the emergence of new pathogens or variants of existing ones. It was also noted that the emergence of certain pathogens (e.g. bat lyssaviruses, hepatoviruses, filoviruses, and hantaviruses) was likely due to heightened awareness and improved detection methods (Yon et al., 2019). The authors concluded by emphasising the significance of integrated monitoring and vigilance of wildlife diseases in Europe to enhance the existing efforts in domestic animal and human health surveillance (Yon et al., 2019). Additionally, they indicated that due to the potential for disease transmission between humans, domestic animals, and wildlife, it is crucial to integrate health surveillance across these three populations (Yon et al., 2019).

Lastly, a study from Queensland, Australia described the use of AI with an 18-year dataset on Q fever to support the identification of potential exposure pathways, and ultimately support the development of better targeted prevention efforts (Clark et al., 2020). Specifically, the natural language processing and topic modelling algorithms were used to analyse patient responses and gain demographic insights. A Markov Random Fields model was also used to examine potential livestock exposure. Additionally, machine learning was used to identify significant factors associated with the hospitalisation for Q fever patients (Clark et al., 2020). Overall, the study highlighted the value of combining follow-up surveillance with text modelling "for unravelling exposure pathways in the battle to reduce the incidence of Q fever and other zoonotic diseases" (Clark et al., 2020, pg. 2141). Moreover, the authors state that the results of their application of AI provide an evidence-base for multifaceted and epidemiologically relevant health promotion campaigns that can complement ongoing Q fever occupational vaccination programmes, raising awareness and reducing disease burdens (Clark et al., 2020).

Personalisation of surveillance and monitoring approaches

There was little evidence in the review that pertained to the personalisation element of the P4 approach. That said, in terms of personalisation, Boffetta & Collatuzzo (2022) indicated that data such as social characteristics, lifestyle factors, lifetime events, and interaction between determinants can be used to predict susceptibility of mental health problems. Moreover, data on an individual's exposure to a certain agent or environment through his/her/their workplace can also predict more personalized health risks. Health data can also be used to inform the choice of career path (Boffetta & Collatuzzo, 2022).

Participatory approaches can enhance the quality of surveillance and the data on which it is based

Finally, in terms of participatory health, information that is provided by individuals can be used to guide physicians in developing programs related to healthy lifestyle habits, based on an individual's risk profile which will improve health knowledge among workers (Boffetta & Collatuzzo, 2022).

Combining multiple data sources alongside expert verification and analysis, has been observed to strengthen One Health[1] focused detection of emerging and re-emerging infectious diseases and toxicities (Mercier et al., 2020). Moreover, including expert analysis in the design can meaningfully support active surveillance for emerging and re-emerging disease or toxicity risks within a specific locality. Mercier et al. (2020) describes the French Epidemic Intelligence System (FEIS). The FEIS is an indicator- and event-based surveillance data system using animal health data, other informal data sources (e.g. media coverage, personal communications), and expert verification and analysis. The study indicates the critical value of such systems including experts who are part of a diverse network with knowledge about a wide range of diseases, diagnostic techniques, and geographical dynamics among others (Mercier et al., 2020). The study explored the performance of FEIS as it compares with another gold-standard surveillance tool for reporting infectious disease outbreaks globally (called ProMed) and found that it performed similarly (Mercier et al., 2020). Additionally, the study found that the network of FEIS experts provided a layer of analysis that ensured that potential threats for a specific jurisdiction, in this case France, were identified and that the necessary information could then be communicated to relevant authorities in a timely way (Mercier et al., 2020).

Similar to the insights of Mercier et al. (2020), Pruvot et al. (2023) provides an example in which the human component is critical to ensuring that larger data sets are well used and of high quality. Whereas the example from Mercier et al. (2020) described a “top-down” expert-led approach, Pruvot et al. (2023) described an example in which a robust “bottom-up” approach to ensuring that high-quality, locally-generated data is feeding into surveillance and response efforts to zoonotic diseases. The study focused on WildHealthNet, a surveillance initiative in Cambodia, Lao People’s Democratic Republic, and Vietnam (Pruvot et al., 2023). The program involves active scanning surveillance involving a network of field

[1] The WHO defines One Health in the following way: “One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes that the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent.” See https://www.who.int/health-topics/one-health

actors, including rangers, local communities, and wildlife centres, to report sick or dead wildlife. The data are collected and managed through two standardised tools called Spatial Monitoring and Reporting Tool (SMART) and the Wildlife Health Intelligence Platform (WHIP), with SMART used for real-time field data recording and WHIP managing georeferenced wildlife health events (Pruvot et al., 2023). After a series of rapid, continuous cycles of pilot field implementation, evaluation, and adjustments to protocols and policies, the tools were observed to enable the seamless recording, real-time transmission, and storage of standardized wildlife health data (Pruvot et al., 2023). Overall, the authors found that long-term commitment, iterative development, and integrated policy and implementation are crucial for the sustainability of these networks (Pruvot et al., 2023). This approach supports pandemic prevention by focusing on early surveillance near wildlife habitats, reducing human encroachment, promoting ecosystem integrity, and addressing major global challenges (Pruvot et al., 2023).

Finally, user-generated data and machine learning have also been suggested as having value to prediction, monitoring, and prevention planning in relation to COVID-19, with a system that may be applicable to other infectious diseases in workplaces (Tkatek et al., 2020). This study used an online check-up form that helped them understand their own infection risks, while also providing data that could be valuable to surveillance efforts (Tkatek et al., 2020). The authors then describe a number of potential proposed control efforts that could be applied based on user generated data (Tkatek et al., 2020), however these comments are speculative.

Key opportunities

The included studies above primarily indicate that using a range of machine learning approaches makes good use of big data or linked or pooled data sets. Although little was said in these papers about improvements in bioinformatics, diagnostics, and communications data, Gupta et al. (2024) have indicated that all of these tools, especially when used in conjunction with existing surveillance data, may help to enhance outbreak prediction and prevention strategies.

Limitations, risks, and challenges

The included studies highlighted a number of potential limitations, risks, and challenges to using big data and/or AI to enhance monitoring and surveillance for zoonotic diseases in occupational settings.

First, the quality of data being used with AI may pose a challenge. In Clark et al. (2020)'s exploration of causal pathways for Q Fever in Queensland, they found that "…reports of 'exposure' [to reservoir animals] may in many cases simply relate to observations of a nearby animal, rather than any meaningful interaction that could represent a transmission pathway…" (pg. 2142). In this case, future research is needed to differentiate between casual animal observations and significant interactions that may represent true transmission pathways for Q fever. Similar data quality questions and considerations were raised in other use cases as well (See Majewska et al., 2021).

Additionally, some valuable datasets come with legal and privacy concerns (Boffetta & Collatuzzo, 2022). Risks to privacy may also cause scepticism about the use of these techniques amongst key stakeholders (Boffetta & Collatuzzo, 2022); similar concerns may also arise in relation to the accessibility and availability of data.

Related to the data quality issue, and of utmost importance to the wider purpose of this project, is the fact that zoonotic disease surveillance and occupational health and safety may not always be closely linked. Because zoonotic diseases can fall into both animal and human diseases categories, and therefore require collaboration and communication across multiple sectors (Gupta et al., 2024), joining up the potential occupational implications for emerging zoonotic diseases may not be straightforward.

Deploying many of the techniques in an ongoing, substantial manner may also be time and financial resource intensive (Boffetta & Collatuzzo, 2022; Gupta et al., 2024; Mercier et al., 2020).

SUMMARY OF KEY FINDINGS

The rapid review identified 3 reviews and 6 primary studies that find promising evidence of the following:

Machine learning is being used to better predict zoonotic disease dynamics that may be relevant to the workplace

- One review indicated that machine learning is useful for working with a wide range of types of data and predict risk factors for specific types of workers.
- One primary study showed that machine learning can be used to predict the emergence of poultry diseases (e.g. avian influenza or Newcastle disease).

Machine learning and big data are being used to support better prevention of zoonotic disease spread in settings relevant to many workers

- One review indicated that the risk factors identified by machine learning techniques can be used to design prevention efforts in occupational settings.
- Three primary studies showed that compiling large datasets and analysing them using machine learning can result in a range of valuable prevention insights, for instance, how and why zoonotic diseases are emerging due to changes in host species populations, geographic spread of hosts, or emergence of new pathogens; refine authorities' understanding of key exposure pathways for illnesses like Q fever; and determine which helminths are most likely to pose an unknown risk to humans.

Machine learning and big data can be used to personalise insights for individuals

- One review found that processed data related to social characteristics, lifestyle factors, lifetime events, and interaction between determinants can be used to predict susceptibility to mental health problems. Moreover, these data can be used in conjunction with data about exposures to agents or environments to quantify individuals' risks of developing occupational illnesses.

Participatory approaches can enhance the quality of surveillance

- Two primary studies underlined the critical role of human experts and practitioner in collecting, managing, and analysing data and insights resulting from big data and AI. One study described how a global surveillance program was strengthened by involving a network of experts to validate and analyse the outputs from the database. Moreover, these experts provided critical jurisdiction-specific insights based on the surveillance data. Another demonstrated that involving a number of on-the-ground stakeholders was of great value for building a large surveillance dataset that can detect issues early and navigate cross-sectoral prevention and management issues.

The review uncovered some key risks, limitations and challenges:

- As with other quantitative approaches, insights are only as good as the data on which they are based, and issues can be magnified when compiling large datasets.
- Linking dataset come with legal and privacy concerns.
- Making linkages between zoonotic surveillance and occupational settings may require changing how some data are collected and structured to effectively link data.
- Building the infrastructure for using these tools well may require significant up-front investments.

Table 2: Summary of included studies (n = 9)

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Clark 2020 Australia Livestock-based agriculture	**Queensland Department of Health**. Accessed data from 1 July 1984 to 31 December 2017 but filtered it to only include Q fever cases from 2001-2017 as follow-up questionnaires were made mandatory in 2001. The Q fever cases were confirmed using either laboratory definitive evidence or a combination of both clinical evidence and laboratory definitive evidence. Q Fever	From 2001 to 2017, 4068 individual cases of Q Fever were analysed, with a median patient age of 39 years, of which 74% were male. The researchers created a separate dataset of 979 cases from 2012-2017 to enhance co-exposure analysis because animal exposure data became more comprehensive following the introduction of an improved surveillance form in 2012. Natural language processing and topic modelling algorithms were used to analyse patient responses and gain demographic insights. A Markov Random Fields model was also used to examined potential livestock exposure. Additionally, machine learning was used to identify significant factors associated with the hospitalisation for Q fever patients.	Survey responses varied across demographic groups, and patients associated with different exposure topics were often clustered in specific geographical regions. The study highlights the value of combining follow-up surveillance with text modelling "for unravelling exposure pathways in the battle to reduce the incidence of Q fever and other zoonotic diseases." (p. 2141) These findings provide an evidence-base for multifaceted and epidemiologically relevant health promotion campaigns that can complement ongoing Q fever occupational vaccination programmes, raising awareness and reducing disease burdens. A prominent finding of this study is that older patients, particularly those living in northern regional areas of Queensland, represent a distinct and high-risk group for Q fever infection.	This study shows that Q fever epidemiology in Queensland is "non-stationary", with exposure factors and hospitalisation risks varying by location. The findings indicate that local investigations are essential to identify the factors associated with infection exposure in the high-risk areas and populations highlighted in this research.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Collatuzzo 2022 Italy General occupational health	Various sources of data Malaria, Zika, dengue	Using socio-demographic, biological, and genetic information, AI was utilised to diagnose, manage, prevent, and make decision about various occupational diseases. Big data can be used to screen, track, and trace infections. Migration maps can also be used to trace the spread of infection. Machine learning can forecast regional transmission dynamics. While real-time data such as camera footage, facial recognition, bank card records, and GPS data can use for monitoring potential contacts between infected people (P4). Zoonotic diseases such as Malaria, Zika, and dengue have also been monitored and controlled through algorithms generated by learning systems and AI (P5).	The review emphasises how AI, through the P4 (Predictive, Preventive, Personalised, Participatory) medicine approach, can diagnose, predict, prevent, and personalise treatment for occupational diseases: Individual data, including genetic testing and medical history, can be stratified by job-specific factors and integrated through machine learning to predict risk factors and diagnose health problems. Machine learning can detect risk factors from genetic data and exposure to harmful substances, helping prevent occupational diseases and enabling the screening of high-risk individuals for primary interventions. Data on an individual's workplace exposure to specific agents or environments can be used to predict personalised health risks. Finally, health information provided by individuals can guide physicians in developing programmes tailored to healthy lifestyle habits based on each person's risk profile, thereby enhancing health knowledge among workers.	P4 medicine signifies a new approach that includes various emerging trends in healthcare. Although not every aspect of P4 can be quickly applied in every healthcare environment, this model is useful for fostering innovation and guiding future priorities. Its application in occupational medicine has been somewhat limited so far, but we believe it presents a fresh framework for the field, potentially leading to greater recognition of occupational physicians as key contributors to medical innovation and the enhancement of well-being.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Gupta 2024 India Veterinary professionals, butchers, animal owners and handlers, livestock and poultry workers, workers in food processing industries, sewage workers, hospital staff, and zoo workers	Various sources of data Many types of zoonotic diseases, including, but not limited to: SARS-CoV, MERS-CoV, SARS-COV-2, actinomycosis, anthrax Crohn's disease, lyme disease, Mycobacterium avium subspecies paratuberculosis (MAP), pasteurellosis, salmonellosis, vibriosis. *Note: This list is not exhaustive; for the complete list of zoonotic diseases, please refer to the original study.*	Microscopy, culture, PCR, and ELISA assays were used to screen Crohn's disease (CD) and MAP infection. Geographical information systems (GIS) have been used to monitor, track, and map vector-borne and water-borne diseases (P12). Ecological data analysis of the site, soil type, water sources, and geology can help predict vector-borne diseases and epidemics. "Global Positioning System (GPS) can be utilised to locate regions of high disease prevalence and to monitor control programs. A combination of GIS and GPS could help develop effective disease control." (P12) Data on animal bite injury can be useful for surveillance.	"Rapid diagnosis, effective surveillance, monitoring, and networking tools are essential to counter and contain the impact of zoonotic diseases, limit their spread, and implement appropriate prevention and control strategies" (p. 11) Currently, quick, reliable, and confirmatory diagnostic tools have been utilised to detect zoonotic infections. They include polymerase chain reaction (PCR), real-time PCR, quantitative PCR, multiplex PCR, loop-mediated isothermal amplification (LAMP), recombinant and natural secretory protein-based ELISA, biochips, biosensors, microarrays, gene sequencing and phylogenetic analysis, as well as nanotechnology-based diagnostics. Strategies for predicting disease outbreaks should be enhanced through the integration of novel mathematical modelling systems to identify unknown pathogens in other species as well as adopt new methods in detecting microbes that are likely to affect humans. Collaboration between veterinary and public health sectors is critical, alongside advanced diagnostics and effective communication, to mitigate the growing threat of zoonotic diseases globally.	Zoonoses have long been recognised and now account for over 300 contagious diseases caused by bacteria, parasites, fungi, and viruses. Tropical and developing regions are particularly vulnerable due to inadequate infrastructure and public health systems. Factors such as changes in demographics, globalization, deforestation, and the rise of international travel contribute to the emergence of these diseases. Addressing these challenges requires coordinated strategies, including vaccine development, enhanced surveillance, and improved management of human-animal-environment interactions.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Kader 2021 Bangladesh Chicken farms	**UCI Machine Learning repository** containing datasets with 30 characteristics of chicken health. Poultry diseases like Avian Influenza and Newcastle Disease	Poultry diseases were predicted using machine learning algorithms. The algorithms utilised 30 chicken characteristics from a dataset to detect the presence of poultry disease in a chicken.	The positive predictive and negative predictive values for each machine learning model were calculated and analysed. Based on the analysis, all the models can be used to predict poultry disease with accuracy rate ranging from 74% to 97%. Random Forest Classifier is the most accurate machine learning model to predict poultry disease with 97% accuracy, while k-nearest neighbour classifier is the least accurate with 74% accuracy.	The research highlights the use of machine learning and data mining algorithms to predict and prevent emerging diseases in the poultry industry, such as Avian Influenza and Newcastle Disease. This is crucial for countries like Bangladesh, where the poultry sector is a significant economic investment and source of animal protein. The study aims to prevent the industry's annual 40% poultry loss from diseases by implementing machine learning prediction. Eleven machine learning algorithms were tested, with the Random Forest Classifier proving the most effective, achieving 97% accuracy and 99% receiver operating characteristic value, making it the best tool for disease prediction.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Majewska 2021 USA Not specified	**Global Mammal Parasite Database** (GMPD) that contains the three main classifications of parasitic helminths that infect wildlife and linked georeferenced data from the **London Natural History Museum (LNHM)** to explored geographical distribution. Also obtained mean gross domestic product and human population data for countries where the species were documented for the most recent year from **World Bank**. Zoonotic diseases caused by helminth species	The GMPD was used to compile data on 700 species of helminths, with additional information on human infections sourced from primary studies. The geographical coordinates of each species in the GMPD were supplemented with host-helminth occurrence data from the London Natural History Museum (LNHM). Economic and population data were obtained from the World Bank, resulting in a final dataset of 737 helminth species and 73 trait variables. The researchers applied an investigator-directed learning algorithm to identify factors contributing to the spill over of helminths from wild animal hosts to humans. They employed a machine learning technique, Boosted Regression Trees (BRT), to predict whether certain helminth species could be transmitted to humans. The analysis considered 73 traits, with adjustments like transforming body size variables to improve accuracy. The model was trained on 80% of the data and tested on 20%, optimising accuracy using parameters such as learning rate and tree depth. Helminth species were ranked by their likelihood of being zoonotic, and the impact of different trait categories on prediction performance was evaluated. Additional models were used to validate the results.	The analysis, based on 73 traits, identified key predictors, with the most important being whether the species infects companion animals, uses fish as intermediate hosts, and the number of locations documented. Geography and transmission traits were most critical, while epidemiological and morphological traits were less influential. The model also predicted three mammal-borne helminths as likely zoonotic. Models that excluded epidemiological traits performed best, while those excluding geographical or transmission traits performed worse.	The study used machine learning to analyse parasitic helminth traits and assess their potential to infect humans, focusing on transmission, geographical, morphological, and epidemiological factors. The findings suggest that helminths found in cats and dogs, as well as those transmitted through fish consumption, pose a higher risk of infecting humans. Although the study examined over 700 species, many parasitic worms, especially those in wildlife, remain poorly understood, with significant gaps in knowledge about their life cycles and transmission. Despite these limitations, the study emphasises the critical role of interactions between wildlife, companion animals, and humans in driving zoonotic infections, particularly in developing countries where parasites in free-roaming animals are often untreated.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Mercier 2020 France Not specified, however the epidemiological surveillance platform was created with members representing different sectors of animal health including farmers, veterinarians, scientists, laboratories, hunters, wildlife services.	**World Organisation for Animal Health** (WOAH), **Food and Agriculture Organization of the United Nations** (FAO), **The European Food Safety Authority** (EFSA), **The European Commission**, and **unofficial sources** (e.g. media, personal communications). If a 'signal' (i.e. "information relating to a health event that could threaten animal populations in France," p. 807) was detected from these sources, a network of international and national disease experts would discuss and verify the information before alerting health professionals. Avian influenza, African swine fever	The French Epidemic Intelligence System (FEIS), an epidemic monitoring platform designed to detect potential emerging zoonotic and epidemic threats, integrated an existing local epidemiological surveillance platform (ESA) with various regional and international data sources. Additionally, FEIS collects event-based surveillance data from diverse sources such as newspaper articles, reports, stories, and personal communications. Experts then analysed this information to provide contextual insights. The study compared the coverage of animal health events reported by the FEIS and ProMED systems from January 2016 to December 2017. ProMED, an initiative of the International Society for Infectious Diseases (ISID), is an internet-based surveillance system that disseminates information on unusual health events related to emerging and re-emerging infectious diseases, as well as toxicities affecting humans, animals, and plants. Data from the FEIS report dashboard, which includes both public and confidential reports on infectious diseases, were evaluated against ProMED posts focused on infectious animal diseases and zoonoses.	The FEIS effectively detected and reported all health hazards identified by ProMED, alerting health authorities and stakeholders when necessary. Compared to international systems like ProMED, which provide general information, the FEIS provided an additional layer of filtering and interpretation focused on animal health threats specific to France, ensuring only essential information was communicated to health authorities. The FEIS network is regarded as highly effective, as it covered all 53 health hazards identified as key concerns by French animal health authorities. Additionally, it monitored 52.6% of the 255 ProMED themes related to infections and zoonoses occurring in Europe. The themes not reported by FEIS were either due to the diseases already being present in France (31.4%), the risk of their introduction into the country being low or negligible (14.1%), or their societal and economic impact being considered minimal (2.0%).	Due to the animal origin of many emerging infectious diseases and the growing interactions between animal and human populations, sharing animal and human data is crucial for improving the detection, management, and prevention of disease spread at national, European, and global levels. The FEIS can enhance its One Health approach by deepening collaborations with public health agencies and other national or international bodies involved in epidemic intelligence, such as the WHO and ECDC, through the exchange of information, expertise, and tools.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Pruvot 2023 USA Wildlife-related professions	**Spatial Monitoring and Reporting Tool** (SMART) for real-time wildlife health surveillance field data and **Wildlife Health Intelligence Platform** (WHIP) for georeferenced wildlife health events, including animal specimen sampled and diagnostics tests conducted on those samples. African swine fever, avian influenza, Rickettsiales, Nipah virus, Hantaviruses, Coronaviruses	The study piloted an integrated one-health approach for zoonosis surveillance involving a network of wildlife workers, experts, and the government. The Spatial Monitoring and Reporting Tool (SMART) and the Wildlife Health Intelligence Platform (WHIP) were selected for data collection and management, with SMART used for real-time field data recording and WHIP managing georeferenced wildlife health events. Procedures for reporting, specimen collection, and lab submissions were agreed upon by field actors and government representatives, following established protocols. These tools were piloted by multiple stakeholders, and their design was iteratively improved based on feedback from field activities.	The WildHealthNet initiative served as a large-scale demonstration of "One Health in Action" and demonstrated its benefits in operationalising wildlife health surveillance. The approach involved rapid, continuous cycles of pilot field implementation, evaluation, and adjustments to protocols and policies which, in turn, enabled the identification of practical and sustainable strategies from the ground up and were eventually incorporated into national standard operating procedures and policies. The authors mention that, to the best of their knowledge, SMART and WHIP are the most comprehensive wildlife information management systems, and are recommended as best practice standards for wildlife health data collection and management.	Long-term commitment, iterative development, and integrated policy and implementation are crucial for the sustainability of these networks. This approach supports pandemic prevention by focusing on early surveillance near wildlife habitats, reducing human encroachment, and promoting ecosystem integrity, addressing major global challenges.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Tkatek 2020 Morocco Not specified, however healthcare workers and other essential workers were mentioned to need more protection	**User-provided data** including personal details (e.g. name, workplace, ID number) and COVID-19 symptoms (e.g. fever, cough, loss of smell, or no symptoms). COVID-19	The study developed a novel system, General Guide (GG) application, using big data and AI. It integrated several algorithms to predict outcomes based on symptoms and inform decision-making. The predictive models applied to GG application include: Logistic regression, Decision tree, and Neural network. The application provided users with information about COVID-19 and allowed them to complete an online check-up that displayed their infection risks.	The prediction results generated by different models in the GG application was tested and compared using Python programming. After comparing and analysing the results from these models, Holt's Linear Model Prediction and the Auto Regressive Model were observed to be the most efficient models for predicting "certain parameters" for a database similar to the one used in this study. There is an opportunity for the concept of this expert system to include other solutions e.g. sanitising systems and multipurpose drones, and be applied to other contagious diseases in the future to help facilitate keeping the situation under control and optimising government resources.	The expert system developed using big data and AI helps prevent the spread of COVID-19 and similar contagious diseases by offering a simplified model for citizens to access COVID-19 information and perform online infection risk check-ups. The collected data aids governments in predicting pandemic trends, allowing them to implement preventative measures like confinement in high-risk areas while keeping low-risk areas open. This system, integrated with additional solutions like sanitizing systems and drones, helps control the pandemic and optimize government resources while minimizing economic impact. The system's preventative focus and accuracy make it applicable to other contagious diseases in the future.

First author (FA) / Year / FA country / Occupational setting	Source of data or occupational health databases used (if any) / Disease type	Summary of methods	Key findings & Research opportunities	Conclusions
Yon 2019 UK Not specified	Information on changes in the epidemiology of infectious pathogens in European wildlife from **European-wide wildlife disease surveillance projects**, including: WildTech, ASF-STOP, EMIDA-APHAEA (European Research on Emerging and Major Infectious Diseases of production Animals - Approaches in monitoring wildlife Population Health, And Ecology and Abundance), ANIHWA-ECALEP (Emergence of highly pathogenic CAliciviruses in LEporidae), and MedVetNet WiREDZ SIG (Special Interest Group in Wildlife-Related Emerging Diseases and Zoonoses) Bat lyssavirus infections, Q Fever, Crimean-Congo haemorrhagic fever, Echinococcosis (hydatid disease), Hantaviruses, Hepatitis E, Filovirus infection, Tularemia, rabies, Salmonella, West Nile virus	This review compiled data from wildlife disease surveillance and conducted a literature review for each disease to provide an update on changes in the epidemiology of selected infectious diseases in European wildlife. 25 wildlife-related diseases were selected based on their: 1) identification as key surveillance targets in recent European-wide projects, 2) inclusion into a pathogens classification that requires obligatory surveillance according to European Union, 3) presence in updated wildlife-related disease literature, 4) inclusion in the key pathogen list by the Office International des Epizooties, 5) repeated identification in a European Wildlife Disease Association conference and mailing list, or 6) identification as pathogens with epidemiological changes during 2010-2016.	Out of the 25 diseases, 12 were identified to have primary impacts on public health, 7 were identified to have primary impacts on livestock health, and 6 were identified to have primary impacts on wildlife conservation and biodiversity. Twelve of the pathogens have also developed new pathogen or pathogen subtype. Results of the surveillance data and literature review showed that the epidemiologic changes in the selected list of zoonotic diseases was typically due to an increase in the number of susceptible host species, an expansion of their geographic range, or the emergence of new pathogens or variants of existing ones. It was also noted that the emergence of certain pathogens (e.g. bat lyssaviruses, hepatoviruses, filoviruses, and hantaviruses) was likely due to heightened awareness and improved detection methods.	The review emphasises the significance of integrated monitoring and vigilance of wildlife diseases in Europe to enhance the existing efforts in domestic animal and human health surveillance. Additionally, due to the potential for disease transmission between humans, domestic animals, and wildlife, it is crucial to integrate health surveillance across these three populations.

References

Included studies

Clark, N. J., Tozer, S., Wood, C., Firestone, S. M., Stevenson, M., Caraguel, C., Chaber, A. L., Heller, J., & Soares Magalhaes, R. J. (2020). Unravelling animal exposure profiles of human Q fever cases in Queensland, Australia, using natural language processing. *Transboundary and Emerging Diseases*, *67*(5), 2133–2145. https://doi.org/10.1111/tbed.13565

Boffetta, P. & Collatuzzo, G. (2022). Application of P4 (predictive, preventive, personalized, participatory) approach to occupational medicine. *La Medicina Del Lavoro*, *113*(1).

Gupta, S., Kaur, R., Sohal, J. S., Singh, S. V., Das, K., Sharma, M. K., Singh, J., Sharma, S., & Dhama, K. (2024). Countering Zoonotic Diseases: Current Scenario and Advances in Diagnostics, Monitoring, Prophylaxis and Therapeutic Strategies. *Arch. Med. Res.*, *55*(6), 103037. https://doi.org/10.1016/j.arcmed.2024.103037

Kader, M. S., Ahmed, F., & Akter, J. (2021). *Machine Learning Techniques to Precaution of Emerging Disease in the Poultry Industry*. 24th International Conference on Computer and Information Technology, ICCIT 2021. https://doi.org/10.1109/ICCIT54785.2021.9689828

Majewska, A. A., Huang, T., Han, B., & Drake, J. M. (2021). Predictors of zoonotic potential in helminths. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *376*(1837), 20200356. https://doi.org/10.1098/rstb.2020.0356

Mercier, A., Lancelot, R., Hendrikx, P., MacKinnon, L., Madoff, L., Lambert, Y., Calavas, D., & Cauchard, J. (2020). *The French Epidemic Intelligence System: Comparing disease surveillance at the national and international level using data from the Program for Monitoring Emerging Diseases*.

Pruvot, M., Denstedt, E., Latinne, A., Porco, A., Montecino-Latorre, D., Khammavong, K., Milavong, P., Phouangsouvanh, S., Sisavanh, M., Nga, N. T. T., Ngoc, P. T. B., Thanh, V. D., Chea, S., Sours, S., Phommachanh, P., Theppangna, W., Phiphakhavong, S., Vanna, C., Masphal, K., … Fine, A. E. (2023). WildHealthNet: Supporting the development of sustainable wildlife health surveillance networks in Southeast Asia. *Sci. Total Environ.*, *863*, 160748. https://doi.org/10.1016/j.scitotenv.2022.160748

Tkatek, S., Belmzoukia, A., Nafai, S., Abouchabaka, J., & Ibnou-Ratib, Y. (2020). Putting the world back to work: An expert system using big data and artificial intelligence in combating the spread of COVID-19 and similar contagious diseases. *Work (Reading, Mass.)*, *67*(3), 557–572. https://doi.org/10.3233/WOR-203309

Yon, L., Duff, J. P., Ågren, E. O., Erdélyi, K., Ferroglio, E., Godfroid, J., Hars, J., Hestvik, G., Horton, D., Kuiken, T., Lavazza, A., Markowska-Daniel, I., Martel, A., Neimanis, A., Pasmans, F., Price, S. J., Ruiz-Fons, F., Ryser-Degiorgis, M. P., Widén, F., & Gavier-Widén, D. (2019). Recent changes in infectious diseases in european wildlife. *J. Wildl. Dis.*, *55*(1), 3–43. https://doi.org/10.7589/2017-07-172

DISCUSSION & POTENTIAL IMPLICATIONS FOR PRACTICE

CROSS-CUTTING THEMES

Notable emerging and re-emerging occupational illnesses and diseases identified

The findings of the expert interviews were largely consistent with the candidate illnesses and diseases identified by WorkSafe Victoria for the 10 profiles. Between the 10 topics ultimately selected, and those that were considered and not selected, all topics raised by the experts were covered. This being said, it is worth underlining the strength of support for greater surveillance and monitoring efforts for a few topics in particular.

Contact dermatitis, occupational asthma, and conditions relating to exposure to welding fumes were all issues that consistently came up throughout the project. Moreover, this group of conditions were frequently mentioned as not getting sufficient recognition and often not being attributed to working conditions. Experts in the interviews, as well as on the author team, believe that each of these have potential to become the next major issue. Making better and faster connections between diseases like these and working conditions can enable both better treatment and prevention. Better treatment can be achieved through removing workers from the conditions making them sick. In the cases of contact dermatitis and occupational asthma, experts reflected that stopping exposure to sensitising agents can meaningfully shape whether a condition is short-lived or becomes chronic. In terms of prevention, better and faster linkage between these conditions and working conditions can mean that all workers in a setting, not just those "in the firing line" can be targeted for prevention and risk mitigation efforts.

Potential implications for practice: Regulators, unions, peak bodies, or other worker groups could fund, organise, and/or implement tailored occupational hygiene trainings for workers in high-risk sectors or in sectors where emerging issues may be present.

Moreover, regulators could develop awareness raising materials, guides for occupational history taking, or other outreach approaches for general practitioners and other relevant health professionals in an effort to identify emerging and re-emerging occupational illnesses and diseases identified in this report earlier.

Emerging infectious diseases, especially those that may spread from non-humans to humans pose a particular set of challenges that are relevant to this project. With climate change and human encroachment on habitats, these issues will continue to be a moving target for general surveillance efforts, as well as for how these surveillance efforts link to workers at risk. The profiles, evidence review, and interviews all demonstrated that there are a range of new tools to undertake monitoring and surveillance for these illnesses, their hosts, or the areas where they may spread – including, geospatial analysis using GIS data, remote sensing, web- and mobile-based data collection tools, drones, and a range of quantitative tools to work with big data to undertake forecasting, among others. Again, a key challenge is linking broader surveillance efforts to the specific needs and conditions or workers who may be at risk in rural and remote regions or who have regular contact with a range of organisms as a part of their work.

Potential implications for practice: Regulators and researchers collaborating to ensure that linkages between existing health-related databases and those from other relevant topics (e.g. climate) are being used maximally to identify emerging and re-emerging occupational illnesses and diseases may be a useful near-term step.

Workers' mental health is also of paramount concern. Mental health conditions were mentioned by nearly all interview participants in addition to being the subject of a profile. While the nature and scale of this issue seems to still be emerging it appears to be relevant to all workers, not only those that might be in highly stressful professions but also individuals who may be at greater risk for mental health conditions. The expert interviewees felt that changes in working arrangements, workplace norms, and worker expectations are all likely to be playing a role in this issue becoming a concern. This said, it should be noted that in relation to working from home arrangements in particular, these have a complex relationship with stress, for instance, working from home misses out on workplace connectedness. On the one hand, it may introduce more stress due to home-related duties; conversely, it may also help reduce stress because workers do not need to commute and therefore their work days are shorter.

Potential implications for practice: Regulators, medical providers, unions, peak bodies, and other workers' groups could develop knowledge exchange activities to consolidate learning about the growing burden of mental health conditions caused by occupational factors, as well as how the changing nature of work may be affecting this emerging issue.

Climate change is going to shape a number of occupational illnesses and diseases in complex ways

Climate change will affect the incidence and prevalence of several occupational illnesses and diseases. Within this work, the heat stress related profile and interview data showed that increasing temperatures will not only affect individual workers through their individual experiences of heat, but also the performance of materials that they are working with (e.g. volatile chemicals in construction) and risk mitigation efforts (e.g. balancing risks to be mitigated by PPE with thermal comfort considerations). Overall, it seems likely that many of the heat-related risks to workers and their workplaces may be identified and monitored using existing or relatively new tools. Conversely, emerging vector borne diseases like JE or MVEV may be much more difficult to attribute to work/working conditions.

Potential implications for practice: Similar to the section on "emerging infectious diseases…" regulators and researchers collaborating to ensure that linkages between existing climate and health-related databases are being used maximally to identify emerging and re-emerging occupational illnesses and diseases may be a useful near-term step.

Big data and machine learning are creating several new opportunities for surveillance

The rapid review and profiles provide support for the idea that compiling or utilising larger datasets, as well as in some cases using relatively new artificial intelligence tools to process these data, holds promise for a number of prediction, prevention, personalisation, and participation applications.

For instance, new data sources are providing better ways to track workplace health risks. The Australian National Occupational Respiratory Disease Registry, launched in 2024, is centralising data on diseases like silicosis to improve monitoring and prevention efforts. Health insurance and Medicare records have also been shown to be valuable tools for tracking long-term disease prevalence and impacts of conditions. Several interviewees mentioned the value of increasingly linking datasets to achieve new insights. However, it must be mentioned that these data need to be accessible and delivered in a timely fashion to be truly useful. These data sources, combined with new technologies, play an important role in improving workplace safety, though ongoing development and investment in monitoring systems will be essential to fully realise their potential.

A few examples from the project where AI-driven technologies are transforming workplace safety monitoring and surveillance include the fact that a range of techniques like neural networks, support vector machines, and decision trees are being employed to identify, classify and prevent COPD with improved accuracy. In silicosis detection, AI-enabled radiology tools, combined with machine learning algorithms, are advancing the accuracy and timeliness of diagnoses. Similarly, in bushfire contexts, AI is also being integrated into air quality monitoring systems to enhance the prediction of PM (particulate matter) 2.5 levels, allowing for more accurate real-time hazard assessment.

Potential implications for practice: Regulators could maintain awareness of the capabilities of AI tools for data processes and the development of insights and deploy them where appropriate within a well-designed ethical/responsible AI framework.

Additionally, data stewards can assess opportunities for using and implementing identifiers or other information/structures to ensure that datasets can be optimally used by emerging AI techniques and tools.

Moreover, regulators, researchers, and other stewards and stakeholders of data can explore partnership opportunities to exchange knowledge about valuable data sets, develop ways to increase the value of data linkage where possible, and/or consider using open data approaches where appropriate and feasible. One practical example of these types of approaches would be, regulators developing a closer understanding of if and how Pharmaceutical Benefits Scheme data could support their role in the community.

Long-term planning, engagement, and support is required

Many of the new monitoring and surveillance approaches mentioned in this project likely have upfront costs in terms or human and financial resources. Both the examples from the participatory section of the rapid review highlight that significant time from experts or on-the-ground practitioners can be required to establish state-of-the-art systems that are resilient, responsive, and capable of navigating the cross-sector complexities of surveillance for some illnesses (in those cases zoonotic illnesses).

More broadly, a consistent message from the interviews was that sufficient long-term support for existing tools like registries and well-designed cohort studies is vital. The Expert members of the author team similarly cannot express strongly enough the value of cohort studies, especially in “high-risk” industries.

The interviews further uncovered that a long-term view is critical when monitoring for illnesses and diseases emerging from workers’ previous employment in risky settings. The transient nature of several forms of employment is an important consideration; in this work hairdressers and seasonal firefighters were two professions highlighted.

To put these points more directly, this report contains a wide range of ways to monitor existing issues and identify new ones, but without sufficient resources to enact some of these, this knowledge will not be put to use.

Potential implications for practice: Regulators, government research funding schemes, private businesses, and/or universities could develop funding opportunities and research infrastructures that ensure the possibility of on-going and/or long-term research. For instance, if a cohort study is initiated through government funding, safeguarding that the funding is allocated for a sufficiently long period for the cohort study to realise its value to the community.

Sensing and monitoring technology are getting a lot better, but still need further improvement and validation in many sectors

The profiles showed that emerging technologies and data sources for surveillance and monitoring will play a significant role in improving workplace safety. Generally, these tools are getting more efficient, effective, and smaller. Good examples are real-time monitoring tools that are being developed for early detection of occupational illnesses and diseases. For instance, portable devices designed to measure Respirable Crystalline Silica (RCS) levels are emerging as valuable tools for early detection of silicosis, though they are still in development. Additionally, in bushfire-prone areas, real-time air quality monitoring systems are being used to track pollutants like PM 2.5 and ozone, which are crucial for protecting outdoor workers. Real-time monitoring of occupational heat stress through wearable sensors, sensor-equipped helmets, and digital skin technologies allows for constant tracking of workers' physiological conditions and environmental factors. While these methods are effective, challenges such as limited coverage and harsh environmental conditions still need to be addressed to ensure comprehensive protection.

It is important to note that the interviews also uncovered the fact that many of these tools still require additional improvement and validation in order to be used as a primary source of safety related data.

Potential implications for practice: Researchers or regulators regularly undertaking monitoring for updates on potential uses and validity of data from new sensors could support the process of integrating them into health and safety practices more efficiently.

Collaboration across sectors and disciplines is key

The previous section underlined the fact that keeping humans in the loop of state-of-the-art surveillance systems is one way to ensure that big data and AI are put to good use. The networks of people in both those examples involve medical, veterinary, agricultural, and public health among others. Some interviewees similarly highlighted that creating infrastructure to better use the existing expertise of nurses and doctors will more quickly help to identify when “a few cases” might be turning into a cluster. Creating ways to listen to these front-line professionals, as well as workers more generally, is a point well supported by this work.

Potential implications for practice: In relation to illnesses that may require substantial cross sectorial collaboration, for example in relation to mosquito-borne infectious diseases, developing or bolstering systems for knowledge sharing, coordination, and shared action between all potentially relevant actors could help to support early identification of emerging issues and holistic mitigation and response efforts. Systems-thinking-related methods like stakeholder mapping could be used to ensure that all relevant actors are identified and engaged.

Greater awareness of occupational illnesses and diseases among workers and healthcare providers would help identify problems while they are still modest in size

This point is well supported across all three sources of data in this project—the profiles, the interviews, and in the Yon et al. (2019) article in the rapid review. The two groups of people whose awareness should be raised based on the project should be front-line medical practitioners and workers themselves. For medical professionals, it was suggested that they be made more aware of the potential occupational contribution to conditions like contact dermatitis, as well as have more supports and tools to ensure that occupational history and/or current working conditions are considered in their day-to-day work with patients. For workers, it is likely gaining more training in occupational hygiene, as well as for organisations to build cultures of safety around them.

Potential implications for practice: Regulators, unions, peak bodies, or other workers groups could fund, organise, and/or implement tailored occupational hygiene trainings for workers in high-risk sectors or in sectors where emerging issues may be present (e.g. outdoor workers in relation to mosquito-borne illnesses, high stress office environments in relation to mental health disorders, or specific areas of the building sector in relation to exposure to new materials).

Moreover, regulators could develop awareness-raising materials, guides for occupational history taking, or other outreach approaches for general practitioners and other relevant health professionals in an effort to identify emerging and re-emerging occupational illnesses and diseases identified in this report earlier.

Examples of registries and databases identified through the research

Finally, the reader should be aware that through this research, the author team identified a range of examples of surveillance systems that may be of interest to WorkSafe Victoria. Please see Appendix 6.

Potential implications for practice: Researchers or regulators regularly undertaking monitoring for research products based on the data from items listed Appendix 6, and/or other similar data sources, would allow for potentially faster uptake of cross-jurisdictional learning and/or the identification of common issues at an earlier date.

SUMMARY OF REGULATOR TAKE AWAYS

- There is a need to investigate opportunities for data compilation and harmonisation and data linkage, and the possibility of harnessing the power and value or AI/machine learning to better monitor emerging illnesses.
- Adequate funding of longitudinal cohort studies or high-risk workers is necessary to monitor illnesses, both in terms of their prevalence and their outcomes.
- Education of both healthcare professionals and workers on the link between work conditions and illness and occupational hygiene would be valuable for managing risks and monitoring emerging illnesses.
- emerging technologies such as wearable devices should be considered as tools that can support workers safety.

References

Bartoli D, Banchi B, Di Benedetto F, Farina G A, Iaia T E, Poli C, Romanelli M , Scancarello G, Tarchi M. Silicosis in employees in the processing of kitchen, bar and shop countertops made from quartz resin composite. Provisional results of the environmental and health survey conducted within the territory of USL 11 of Empoli in Tuscany among employees in the processing of quartz resin composite materials and review of the literature, Ital. J. Occup. Environ. Hyg., **2012**, 3(3) | 143 https://www.ijoehy.it/index.php/IJOEHY-ARCHIVE/article/view/126

Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006 Jan;3(2):77–101.

Frankel A, Blake L, Yates D. Complicated silicosis in an Australian worker from cutting engineered stone countertops: An embarrassing first for Australia. European Respiratory Journal 2015 46: PA1144; DOI: 10.1183/13993003.congress-2015.PA1144 https://erj.ersjournals.com/content/46/suppl_59/PA1144

Hoy R F, Dimitriadis C, Abramson M, Glass D C, Gwini S, Hore-Lacy F, Jimenez-Martin J, Walker-Bone K, Sim M R. Prevalence and risk factors for silicosis among a large cohort of stone benchtop industry workers. Occup Environ Med 2023;80:439–446. doi:10.1136/oemed-2023-108892 https://oem.bmj.com/content/early/2023/06/16/oemed-2023-108892.full

Kramer M R, Blanc P D, Fireman E, Amital A, Guber A, Rhahman N A, Shitrit D. Artificial Stone Silicosis. Disease Resurgence Among Artificial Stone Workers Original Research | Occupational And Environmental Lung Diseases| Volume 142, Issue 2, p419-424, August **2012** DOI:https://doi.org/10.1378/chest.11-1321 https://journal.chestnet.org/article/S0012-3692(12)60455-3/abstract

Lumivero (2023) NVivo (Version 14) www.lumivero.com

Pascual S, Urrutia I, Ballaz A, Arrizubieta I, Altube L, Salinas C. Prevalence of silicosis in a marble factory after exposure to quartz conglomerates. Arch Bronconeumol. **2011** Jan;47(1):50-1. English, Spanish. doi: 10.1016/j.arbres.2010.09.004. Epub 2010 Dec 28. PMID: 21190766. https://pubmed.ncbi.nlm.nih.gov/21190766/

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

APPENDIX 1 – INTERVIEW FRAMEWORK

Practice interview framework

Conduct a rapid review of research evidence and practice to learn about emerging or re-emerging occupational diseases and illnesses and novel surveillance and monitoring approaches to identify and address them.

Consent?

Questions will be tailored to particular topics, but may include a selection of the following:

- Can you describe your role and how it is related to the topic of this research?

- Are there new and emerging data sources for disease markers to assist public health monitoring for workplace safety in the next five years and beyond? IF YES, ***Probes:***
  - Where is this based?
  - What is the strength of this new system?
  - Are there new indicators that are being used that are of value to this conversation?
  - Are there other analytical techniques being applied?

- Is there anything else that we should know that is important to our conversation about the above questions?

Optional: are there other experts who we should be talking to about this?

Appendix 2 – Explanatory statement

Explanatory Statement: practice interview

Title of study: What is currently known about new surveillance and monitoring strategies for identifying emerging and reemerging occupational diseases and illnesses?
Project ID: 30009
Principal Investigator: Peter Bragge, PhD, B. Physio (Hons.)

We are conducting the above project funded by WorkSafe Victoria. The aim of this project is to:

Conduct a rapid review of research evidence and practice to learn about emerging or re-emerging occupational diseases and illnesses and novel surveillance and monitoring approaches to identify and address them.

You have been invited to participate in an interview of 30-45 minutes to reflect on your experience and / or expertise regarding occupational illnesses and diseases and/or public health surveillance and monitoring approaches. The interview will be conducted online using the *Zoom* platform, via phone call, or in person – whichever is preferred by you.

Data will be gathered from the interview in the form of notes and an audio recording. The audio will be transcribed into written notes by a recognised third-party transcription service used by Monash University on a regular basis (rev.com). All transcriptionists are vetted through a rigorous screening process, receive training in best practices for security and privacy and have signed confidentiality agreements. The data gathered will be aggregated with data from other interviews and thematically analysed. The thematic analysis will become part of a report that will be delivered to WorkSafe Victoria. We may also publish findings in peer-reviewed academic journals or online platforms such as *The Conversation.* You can request information about available project outputs by emailing paul.kellner@monash.edu.

Short quotes from your interview may be used to illustrate particular themes. Your name will not be identified in any publications or presentations and no potentially identifying information (for example, a geographical region or place of work) will be included in any quoted comments.

If you consent to participate in an interview, please complete and send the written consent form attached to the invitation email to paul.kellner@monash.edu or click here to access the online version. If you do not send a completed consent form, you will be asked to indicate your consent at the beginning of the interview. It is important for you to know that you can choose not to take part in this study. You can withdraw your consent at any time, including after you have completed the interview. If you withdraw, your data will also be withdrawn from the study. The latest date to withdraw consent is the 1 October 2024, after which point the withdrawal of data will no longer be possible as we will have disseminated the study results.

The benefit to you of participating in this study is that your perspectives can help enhance understanding of about emerging or re-emerging occupational diseases and illnesses and novel surveillance and monitoring approaches to identify and address them. This understanding can inform strategies that are ultimately designed to improve policy, practice, or research.

Data from the interview will be considered confidential. We will ensure that hard copy material is kept in a locked cabinet and that electronic data is stored on a security-protected computer, with restricted access limited to the Monash University staff directly involved in this project. Your anonymity as a research study participant will be safeguarded. The data from your interview will be retained for a minimum of seven years following any publication(s) associated with this research. After this time, the data will be destroyed by permanent deletion if it is no longer required.

Thank you for your valuable contribution to our research study. If you have questions or would like additional information, please do not hesitate to contact me. If you have any questions regarding your rights as a research participant specifically, or concerns about this project, you may contact the Executive Officer, Human Research Ethics, Research Office, Chancellery Building D, MONASH UNIVERSITY VIC 3800. Tel: +61 3 9905 2052, Fax: +61 3 9905 3831

Yours Sincerely,

Peter Bragge, PhD, B. Physio (Hons.)
Associate Professor & Director of Health Programs, BehaviourWorks Australia; Lead, Monash-McMaster Social Systems Evidence Collaboration

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APPENDIX 3 – CONSENT FORM

Consent form: practice interview

Project title: What is currently known about new surveillance and monitoring strategies for identifying emerging and reemerging occupations diseases and illnesses?
Project ID: 30009
Chief Investigator: Peter Bragge, PhD, B. Physio (Hons.)

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	Yes	No
• Audio recording during the interview	☐	☐

Name of Participant ____

Participant Signature ____________________ Date __________________

Appendix 4 – Rapid review eligibility criteria

Research question 1 (eventually refined): Methods for occupational disease/illness surveillance or monitoring

	Include	Exclude
Publication Type	• Peer-reviewed journal articles (both reviews and primary studies) • Conference papers • Grey literature	• All other document types e.g. theses, book chapters
Language of Publication	• English	• Non-English
Population / context	• Workers of any type • Workplace / occupational environments (including working at home or non-traditional work settings e.g. gig work)	
Study Focus	• Describes a method or approach to doing surveillance/monitoring of workplace safety and/or occupational illnesses or diseases of any kind (this could be a broad range of things, including, standard surveillance using a registry or database, new analytical techniques like linking data or using machine learning, or even new devices like wearable or sensors) • Focus on emerging or re-emerging workplace safety issues and/or occupational illnesses or diseases of any kind	
Outcomes	• All outcomes	
Date Range	• 2019-present	• 2018 and prior

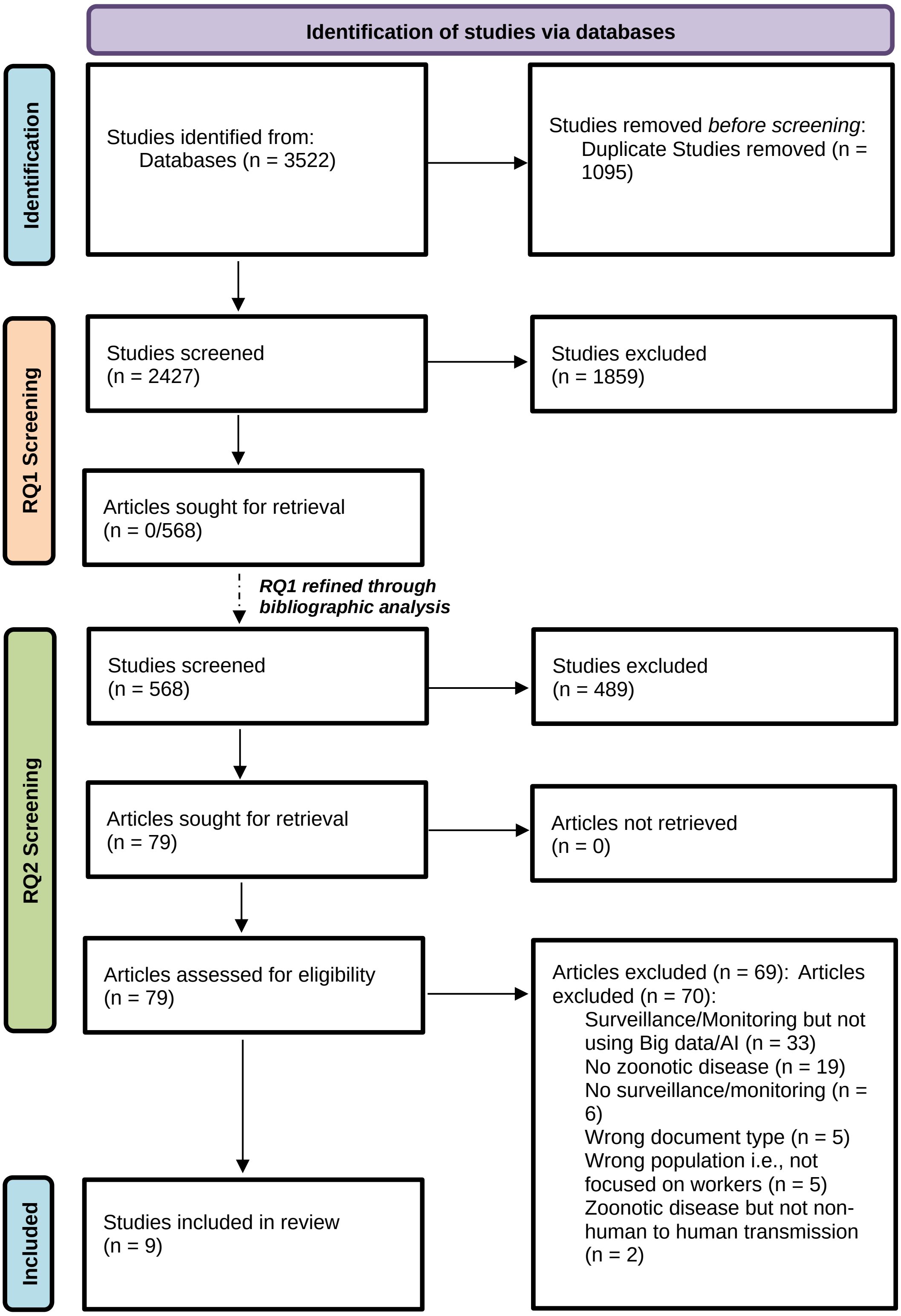
REVIEW QUESTION 2: HOW ARE BIG DATA AND ARTIFICIAL INTELLIGENCE BEING USED TO BETTER UNDERTAKE SURVEILLANCE AND MONITORING FOR ZOONOTIC DISEASES IN OCCUPATIONAL SETTINGS?

	Include	Exclude
Publication Type	• Peer-reviewed journal articles (both reviews and primary studies) • Conference papers	• All other document types, e.g. theses, book chapters
Language of Publication	• English	• Non-English
Population / context	• Workers of any type • All work contexts e.g. outdoor work of various kinds, in rural settings, adjacent to water, etc.	

Study Focus	• Surveillance or monitoring using big data and/or artificial intelligence (AI) technique
	  ○ big data refers to very large datasets, which may be structured or unstructured, that make it challenging to use traditional statistical methods e.g. google search, linking/combining multiple datasets
	  ○ artificial intelligence refers to technology that simulates human learning e.g. machine learning, deep learning, data mining, etc).
		• Does not describe a surveillance or monitoring approach that involves big data and/or AI

Outcomes	• Zoonotic disease of any kind ○ Zoonoses refer to infectious disease caused by any type of pathogen (e.g. virus or bacteria) that jumps from non-human to humans (e.g. vector-borne diseases like malaria, Q fever, etc)	
Date Range	• 2019-present	• 2018 and prior

APPENDIX 5 – RAPID REVIEW PRISMA FLOW DIAGRAM OF THE STUDY SELECTION PROCESS



APPENDIX 6 – SURVEILLANCE PROGRAMS

Surveillance programs:

- Australia Mesothelioma registry, cancer registry and new dust disease registry
- The Health and Occupation Research (THOR) program in UK
- Europe national register of occupational disease
- iReport Singapore occupational disease registry
- United States IIF (Injuries, Illnesses, and Fatalities)
- Malaysia Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease (NADOPOD)
- Turkey SSI (Social Security Institution)
- Finland FROD (Finnish register of occupational disease)
- France RNV 3
- CAREX (CARcinogen EXposure)
- National Occupational Mortality Surveillance (NOMS) in US
- Occupational Disease Surveillance System (ODSS) in Ontario, Canada
- Deutsche Gesetzliche Unfallversicherung - DGUV (German Social Accident Insurance that covers occupational disease and injury and publishes occupational disease and injury statistics)
- SafeWork Australia's NDS
- Czech National Registry of Occupational Disease
- The Singapore Ministry of Manpower keeps a registry
- Duke Health and Safety Surveillance System (DHSSS) (https://pubmed.ncbi.nlm.nih.gov/15164397/)
- Exposure Prevention Information Network (EPINet)
- Incident Management System (IMS+) New South Wales (https://www.ehealth.nsw.gov.au/solutions/clinical-care/quality-safety/ims)
- Victorian Healthcare Associated Infection Surveillance System (VICNISS) (https://www.vicniss.org.au/about/surveillance-activities-in-our-hospitals/)
- Workplace Health Indicator Tracking and Evaluation (WHITE) Database (https://pubmed.ncbi.nlm.nih.gov/19149390/)