Review Article

The Singapore Green Plan 2030: occupational health hazards in the Singapore green economy

Wei Xiang Lim[1], MBBS, MPH (OM), Mei Ling Licia Tan[1], MB BCh BAO (Hons), FAMS (OM), Tzu Li Sylvia Teo[2], MBBS, MMED (OM), Wee Hoe Gan[3], MBBS, FAMS, Shiu Hong Joshua Wong[1], MBBS, FAMS

[1]Department of Occupational Medicine, Sengkang General Hospital, [2]Family Medicine Services, KK Women's and Children's Hospital, [3]Department of Occupational and Environmental Medicine, Singapore General Hospital, Singapore

Abstract

The Singapore Green Plan 2030 was released by the Singapore government to set targets for sustainability by 2030. The adoption of novel technologies, processes and substances creates new jobs, and such developments bring about new challenges and risks for both employers and workers. Beyond emerging hazards, traditional hazards still remain, but they may take on new forms through new work processes. This review aims to provide an overview of the potential occupational health issues we may encounter or anticipate in these key sectors: solar energy, waste management and recycling, green buildings, electric vehicles and battery recycling, and sustainable fuels. While existing Occupational Safety and Health regulations in Singapore serve as a foundation, there may be gaps in addressing the specific hazards and risks associated with green jobs. In this review, we propose and outline possible approaches to the protection of worker safety and health.

Keywords: Green economy, Green Plan, occupational medicine, sustainability, workplace safety and health

INTRODUCTION

The Singapore Green Plan 2030 (Green Plan) is a nationwide movement towards sustainability. It was released by five ministries in February 2021 to chart ambitious yet concrete targets over the next 10 years, reinforcing Singapore's commitments under the United Nation's 2030 Sustainable Development Agenda and Paris Agreement, putting us in a position to meet our goal of net zero emissions by 2050.[1]

As this green revolution gains traction, it expands job opportunities in traditional 'green' industries such as waste management and landscaping. The introduction of novel technologies, materials and work processes also creates new jobs. Such developments bring new challenges and risks for both employers and workers,[2] which may call for technical, political, administrative and regulatory responses to safeguard worker safety and health.[3] The medical community should watch for any emerging occupational health issues and take timely actions to mitigate their effects. This review provides an overview of the potential occupational health issues we may encounter in the Singapore workforce.

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GREEN JOBS

The International Labour Organisation defines green jobs as jobs that contribute in some way to the preservation or restoration of the environment. Green jobs include those that help to preserve ecosystems and biodiversity, lower energy and consumption of raw materials, and decrease pollution and waste.[4] There are five key pillars in the Green Plan — City in Nature, Sustainable Living, Energy Reset, Green Economy and Resilient Future. Table 1 shows the list of typical jobs that we have derived based on the activity areas within the five key pillars.

Importance of occupational safety and health

We often link the term 'green' with safety because green jobs safeguard and preserve our environmental resources. However,

Correspondence: Dr Wei Xiang Lim, Senior Resident, Department of Occupational Medicine, Sengkang General Hospital, 110 Sengkang East Way, 544886, Singapore. E-mail: weixiang.lim@mohh.com.sg

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Table 1. Green jobs in the Singapore Green Plan 2030.

Pillar	Activity areas	Representative jobs
City in Nature	Expand the nature park network	Civil engineers, gardeners
	Intensify nature in gardens and parks	Gardeners, horticulturists
	Restore nature into the urban landscape	Landscapers, urban farmers
	Strengthen connectivity between Singapore's green spaces	Civil engineers, construction workers
	Enhance veterinary care and animal management	Veterinary services
Sustainable Living	A zero-waste nation and circular economy	Waste workers, cleaners, recyclers
	Eco stewardship programme	Civil engineers, policymakers, researchers, academics, innovators
	Green commutes	Drivers, railway track layers, electricians, welders, metal fabricators, engine assemblers
Energy Reset	Green energy	Electrical engineers, electricians, mechanics, welders, electrical equipment assemblers, power grid workers, energy traders
	Green transport	Vocational drivers, mechanics
	Green buildings	Construction managers, building inspectors, architects, heating/air conditioning installers, carpenters, roofers, insulation workers
Green Economy	Decarbonisation	Green process designers, civil engineers, power grid workers, energy traders
	Research and innovation, sustainability initiatives	Policymakers, researchers, academics, innovators
Resilient Future	Shoring up our coastal and flood defence	Civil engineers
	Strengthen food security	High-tech farmers, food processing workers, production workers
	Keep Singapore cool	Urban planners, climate researchers, heating/air conditioning installers

what is beneficial for the environment may not be beneficial for the safety and health of workers in these jobs. The emerging risks associated with green jobs can be summarised as follows: (a) emerging hazards (hazards that are new and have not been identified); (b) traditional hazards — in the haste to generate these new jobs in large numbers, occupational safety and health (OSH) becomes an afterthought and these hazards can be unfamiliar to many workers entering the rapidly expanding 'green' industries; (c) new hazards — new tasks and the need to work with others may pose new hazards that are unfamiliar to the experienced worker (e.g., installation of a solar water heater exposes plumbers and electricians to new hazards and requires them to work with roofers).

It has been shown that substituting environmentally hazardous products with more ecologically friendly ones poses a greater risk to the health of the employees. For instance, when replacing solvent-based paints with water-based paints, paint manufacturers introduce biocides to protect water-based paints from bacteria and fungi, and this may cause allergic reactions in the respiratory system and skin.[5] Also, the risk of exposure to carcinogens and fire hazards has increased due to the substitution of hydrochlorofluorocarbons for chlorofluorocarbons.[6] However, there can be significant health co-benefits associated with the transition to cleaner household energy sources in developing countries, particularly in reducing the health impacts of traditional biomass and coal stoves, which are responsible for millions of premature deaths annually.[7] Adopting clean technologies not only mitigates climate change, but may also substantially improve public health outcomes, particularly for vulnerable populations such as women and children.

Occupational health risks

Taking reference from the Green Plan, we have identified a few key sectors where we anticipate new or emerging occupational health hazards that may require more attention.

Solar energy

Singapore is one of the most solar-dense cities in the world today. At Tengah reservoir, an inland floating solar photovoltaic (PV) system with a peak power of 60 MW was put into service in 2021. Plans are in place to maximise the installation of solar panels in open areas such as reservoirs, rooftops and other areas.

Concentrating solar power and PV panels are two main ways to turn solar energy into electricity. The most popular type of PV system generates energy using semi-conductors and sunlight. There is occupational risk to workers when they manufacture, install and dispose of PV panels. The production process of PV panels involves the usage of more than 15 hazardous chemicals.[8] In addition, conventional hazards such as ergonomic risk factors during the production and installation of solar panels remain relevant. Table 2 summarises the common activities involved in solar cell production and decommissioning, referencing a report by Electric Power Research Institute and California Energy Commission,[8] and their associated health hazards and biological effects based on National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards.[9] While the NIOSH Pocket Guide to Chemical Hazards provides valuable information on the potential health risks of various chemicals, these risks are not absolute and depend on factors such as exposure levels, control measures and individual susceptibility. Understanding and managing these factors are essential for ensuring workplace safety and health.

Table 2. Types of solar cells and associated health hazards.

Type of activities	Hazardous material	Reported safety risks and biological effects
Production of crystalline silicon and amorphous silicon solar cells	Silane gas	Flammable; irritation to eyes, skin and mucous membranes
Production of cadmium telluride solar cells	Cadmium	Metal fume fever, pneumonitis, pulmonary oedema in acute poisoning; renal dysfunction; emphysema; anaemia; osteoporosis; lung carcinogenicity;[9] elevated risk of prostate, kidney and bladder cancers
Production of copper indium selenide solar cells	Hydrogen selenite	Irritation to eyes, skin and mucous membranes; bronchitis; liver and kidney toxicity
Production of gallium arsenide high-efficiency solar cells	Arsenide	Potentially fatal in acute poisoning; ulceration of nasal septum; chronic bronchitis; chronic hepatitis; peripheral neuritis; genotoxicity; lung, bladder and skin carcinogenicity
Wafer production	Dopant gases and vapours such as phosphorus oxychloride, arsine, phosphine and diborane	Flammable; irritation to eyes, skin and mucous membranes; pneumonitis, pulmonary oedema; arsine has similar health effects as arsenide (see above)
Wafer cleaning	Acids such as hydrofluoric acid and nitric acid, and alkalis such as sodium hydroxide	Burns and irritation
Decommissioning (photovoltaic end-of-life materials)	Lead solder from electronic circuits	Anaemia; gastrointestinal tract irritation; paresis, encephalopathy; neurodevelopmental disorders; chronic nephritis; fetotoxicity[10]
	BFR, PBB and PBDE	Potential endocrine disrupters; potential neurodevelopmental disorders[11]

BFR: brominated flame retardants, PBB: polybrominated biphenyls, PBDE: polybrominated diphenylethers

Waste management and recycling

Singapore's Zero Waste Masterplan was introduced in 2019 to steer Singapore towards a circular economy that maximises resource reusage. The target is to decrease the quantity of waste (per capita) that ends up in landfills by 30% by 2030.[10]

Even in developed countries, recycling work can be unclean, polluted, undesirable, unsafe and frequently lowly paid. Due to poor work practices, workers at a UK electrical waste recycling facility developed mercury poisoning when they recycled eco-light bulbs that contained mercury.[11] In the USA, heavy metal poisoning, work-related musculoskeletal disorders, respiratory disorders and skin diseases are common causes of illness in this sector.[12] Waste sorting also involves the risk of exposure to biological agents, including micro-organisms that can lead to respiratory and gastrointestinal disorders, eczema and allergies.[13]

The main occupational health hazards in this sector are heavy manual labour and exposure to heavy metals, organic pollutants and bioaerosols. In 2024, two workers passed away after inhaling hydrogen sulphide gas while draining sludge at a wastewater plant.[14] Working in confined spaces is regulated by Singapore legislation, and extensive guidelines and technical advisory have been published.[15,16] This incident again highlights the risk that traditional hazards can be unfamiliar to workers entering the rapidly expanding green industries, and key OSH procedures may potentially be overshadowed by organisational pressure to increase work output. Exposure to bioaerosols has been linked to a range of symptoms affecting the eyes, nose, throat and respiratory system, which can manifest as irritant and allergic or toxic reactions.[17] In addition to sensitisation to *Aspergillus fumigatus* and actinomycetes spores, abnormal lung function, bronchial hyper-reactivity and elevated inflammatory markers in the nasal fluid, sputum or serum were also found in compost workers. However, it is unknown whether workplace exposures increase the risk of allergic disease development.[18] Table 3 summarises the common recycling activities and the associated recycled materials and health hazards.

Green buildings

A green building is defined as one that uses resources more efficiently at every stage of its existence, including planning, designing, building, operating, maintaining, renovating and demolishing.[19] However, practices meant to improve safety and health usually benefit the final occupants of the building and do not necessarily improve the health and safety of the workers involved in its construction.[20] To enable workers to carry out their duties safely may require skill development and training beyond what is required for traditional buildings,[21] e.g., planting vegetation on the roof or installing solar panels.

Green building sites are not spared from traditional issues such as working at height, slips, trips and falls.[22] In 2023, a construction worker fatally fell from a height of 10 m through a skylight and another worker died after being electrocuted.[23,24] Both workers were installing solar panels on the rooftop of a building. Employers should be pre-emptive and should provide sufficient education and training surrounding the hazards of a green job. Workers installing solar panels need to understand that electrocution and fall from height are major risks. Some relevant examples of traditional hazards that present new risks include solar panels producing live electrical currents when exposed to sunlight even when not connected to a power source[25] and certified green building incorporating more complex design features that could pose greater installation risks as compared to conventional designs.[26] Employers will

Table 3. Hazards and health effects by type of recycling activities and materials.

Type of recycling activities and materials	Hazards to health	Reported clinical and biological effects
Composting, municipal solid and toxic waste	Heavy manual handling, inorganic dust, bioaerosols, VOCs, PAHs, heavy metals, dioxins, furans	Fatal and non-fatal injuries, MMI, OA, EAA, ABPA, asbestos-related lung disease, abnormal lung function, gastrointestinal disease, contact dermatitis, Q fever, leptospirosis
Metals, batteries, cables, wires and catalytic converters	Inorganic dust, lead, other heavy metals include nickel, cadmium, cobalt, manganese, mercury and platinum, noise, radioactive materials, dioxins, furans	Lead poisoning in lead-acid battery, raised urinary mercury in alkaline battery workers
Glass (including leaded glass in cathode ray tubes)	Noise, lead, glass fragments	Injuries, MMI, raised blood lead
Fluorescent lights	Inorganic dust, metal fume, mercury, lead, yttrium	Mercury and lead poisoning, MGN and nephrotic syndrome
Landfill waste	Inorganic dust, bioaerosols, asbestos, gases	MMI, respiratory, dermatological and gastrointestinal symptoms
Textiles	Organic dust, bioaerosols	MMI, respiratory symptoms, abnormal lung function tests, byssinosis, COPD, OA
Wood, chipboard and bark chippings	Dust, bioaerosols	Acute pulmonary aspergillosis from bark chippings; OA from burning wood; MMI, OA, EAA, COPD from manufacturing with wood
Medical waste	Sharps, blood-borne viruses, radioactive materials, heavy metals in incinerator ash	Seroconversion from sharps injury
Paper	Organic contamination, bioaerosols	MMI, OA, sensitisation to storage mites
Waste electronic electrical equipment	Heavy manual handling, inorganic dust, PAHs, heavy metals, dioxins, furans, brominated diphenyl ethers (flame retardants)	Respiratory symptoms, abnormal lung function, adverse neonatal outcomes, chromosomal aberrations, argyria

ABPA: allergic bronchopulmonary aspergillosis, COPD: chronic obstructive pulmonary disease, EAA: extrinsic allergic alveolitis (hypersensitivity pneumonitis), MGN: membranous glomerulonephritis, MMI: mucosal membrane irritation, OA: occupational asthma, PAH: polycyclic aromatic hydrocarbons, VOCs: volatile organic compounds

also need to take precautions against these risks by stopping electrical work during bad weather and implementing a site-specific fall prevention plan to mitigate risks. To reduce energy use, green buildings typically include more extensive insulation and tighter sealing. This results in reduced ventilation during internal finishing works, increasing the concentration of and exposure to dust (e.g., crystalline silica) and volatile organic compounds from paints and adhesives.[20,22] Reinsulating an existing building may expose occupants to traditional insulation materials, such as man-made mineral fibres (e.g., glass wool, rock wool).[27] When these materials are cut or sawed, fibres that can cause dermatitis, eye discomfort and respiratory disorders are released. The sensitising effect of materials employed as binders and additives (e.g., phenol formaldehyde resins) that enhance mineral wool's useful qualities could pose a further risk.[28] Polyurethane foam, frequently used as an alternative, contains isocyanates that can irritate the respiratory tract, mucous membranes of the eyes and gastrointestinal tract, and cause allergic asthma and contact dermatitis.[29]

Retrofitting older buildings with energy-efficient heating and hot water systems usually involves known risks associated with traditional trades like sheet metal fabrication, pipe fitting, electrical work, etc. These include the physical strain of manually moving large machinery, the possibility of asbestos and silica dust exposure during removal, and other health risks from exposure to noise and vibration caused by drilling.[30]

Electric vehicles and battery recycling

The Green Plan includes a strong push towards electric vehicles (EV) to allow Singapore to accomplish the vision of 100% cleaner energy vehicles by 2040. Like its traditional counterparts, EV batteries may explode and cause fires if not handled properly. Workers are also subject to possible high-voltage (300–500 V) electrical hazard at work, increasing electrocution and arc flash risks.

Recycling EV batteries prevents the heavy metals and hazardous chemicals within the batteries from polluting the environment. Three battery recycling plants will grow Singapore's battery recycling capacity by 30% to 11,000 tonnes per year.[31] The process of recycling and recovering materials and metals from used batteries is a mechanical process where the cells are crushed and ground into an intermediary product known as black mass, which contains cobalt, manganese, nickel and lithium.[32] Table 4 outlines the typical composition of materials found in a lithium-ion cell and their associated health effects.[9,33] The black mass can be further processed chemically to extract and upcycle precious metals for new battery production.

Sustainable fuels

As part of the National Hydrogen Strategy vision, low-carbon hydrogen and hydrogen-derived fuels such as ammonia has emerged as a potential fuel for power generation, as well as a low-carbon option for marine and aviation applications. Hydrogen is expected to meet up to 50% of Singapore's

needs by 2050.[34] Hydrogen gas has a very low boiling point and flash point, making it very flammable and explosive. Liquid hydrogen and hydrogen-derived fuels pose risks of asphyxiation and frostbite injuries during handling or leakage incidents. The additional health hazards of ammonia primarily stem from its toxicity, and these hazards include eye and respiratory tract irritation.[35]

The Civil Aviation Authority of Singapore has developed the Singapore Sustainable Air Hub Blueprint to accomplish net zero emissions from domestic and international aviation by 2050. Creating an ecosystem to facilitate Singapore's usage of sustainable aviation fuel (SAF) is part of the strategy.[36] While SAF is designed as cleaner alternative to convention aviation fuel types, it comes with additional health hazards and risks.[37] It may contain mainlyisoparaffins, as well as n-paraffins and hundreds of chemical compounds.[38] Exposure to such a wide range of compounds can trigger health effects on workers during the various manufacturing and application processes such as aircraft refuelling and maintenance of fuel systems.

Certain methods of producing ethanol from waste materials like wood chips and wastepaper require concentrated acids and bases that react violently with a variety of compounds. These often lead to over-pressurising of pipes and equipment if the gases generated during fermentation are not appropriately vented. Organic oils and alcohol also undergo chemical reactions to make biodiesel, usually with the help of a strong base as a catalyst. Explosions, fires, equipment and pipe breaks, and chemical exposures can result from the uncontrollable response of potentially hazardous substances.[39]

THE WAY AHEAD: OCCUPATIONAL HEALTH AS AN INTEGRAL PART OF THE GREEN PLAN

In Singapore, workplace health and safety is governed by the Workplace Safety and Health Act (WSHA) and its subsidiary legislations.[40] Together with approved codes of practice and guidelines, it provides detailed statutory requirements and standards for various aspects of workplace safety and health, such as risk assessments, safety management systems, personal protective equipment and management of hazardous substances. While the WSHA has been updated over the years, some of its subsidiary legislations, particularly the Statutory Medical Examination (SME) regulation introduced in 1985, may need to be reviewed to ensure that it remains relevant and effective.

Table 4. Typical composition of materials found in a lithiumion cell and associated health hazards.

Component	Material (typical mass)	Reported clinical and biological effects
Cathode active powder	Lithium-transition metal oxides – commonly contains nickel, cobalt and manganese (30–40%)	• Cobalt is a Class 2A/2B (depending on compound) carcinogen for lung cancer;[30] lung diseases such as interstitial fibrosis and pulmonary hypersensitivity; skin sensitizer, causing allergic contact dermatitis • Manganese can cause damage to the central nervous system (manganism), resulting in behavioural and neurological symptoms • Nickel is a Class 1 carcinogen for the nasal cavity, paranasal sinus and lung;[30] cardiovascular disease; asthma; lung fibrosis; allergic dermatitis • Lithium is a respiratory tract irritant; acute exposures can cause neurological symptoms such as muscle weakness, tremors and even seizures; long-term exposure may affect renal and cardiac functions, and thyroid functions at higher exposures[8]
Anode active powder	Mostly graphite, carbon black (15–25%)	• Graphite dust can cause irritation to the eyes and respiratory lining • Carbon is a Class 2B carcinogen for lung cancer;[30] chronic respiratory diseases
Separator	Plastic, such as polyethylene, poly propylene, etc., (3%)	–
Binder	Polyvinylidene fluoride (0.6–1.5%)	–
Negative current collector	Copper (15%)	Irritation to eyes, skin and mucous membranes
Positive current collector	Aluminium (10%)	Irritation to eyes, skin and mucous membranes
Casing	Aluminium, steel (5–15%)	Irritation to eyes, skin and mucous membranes
Electrolyte components	Including but not limited to: • Ethylene carbonate (12–15%) • Diethyl carbonate (12–15%) • Dimethyl carbonate (12–15%) • Ethyl methyl carbonate (12–15%) • Propylene carbonate (1.5–2%) • Lithium hexafluorophosphate (1.5–2%)	Shredded lithium-ion batteries generate large quantities of electrolyte vapours, consisting mainly of organic solvents; these vapours produce a strong ethereal odour and can be irritating to the eyes and respiratory tract with prolonged exposure causing renal damage
Electrolyte additives	Including but not limited to: • Vinyl carbonate • Lithium difluorophosphate • Fluoroethylene carbonate (% unknown for all)	Similar to those of electrolyte components

With the shift towards a green economy and Singapore's Green Plan 2030, new industries and job roles are emerging. These may involve exposure to different occupational hazards not adequately covered by the existing SME framework. Medical diagnostic techniques and occupational health monitoring technologies have significantly improved since 1985. The regulation may also need to be updated to incorporate more modern and effective health screening methods. Updated regulations could potentially shift the focus towards a more preventive approach to occupational health, rather than just the detection of existing conditions. Organisations involved in green initiatives, such as renewable energy, waste management or sustainable construction industries, are expected to adhere to the same OSH standards as other industries. However, they may need to adopt additional safety protocols specific to their operations, particularly if they involve working with hazardous materials or unconventional processes. While existing OSH regulations in Singapore provide a foundation for workplace safety and health, there may be gaps in addressing the specific hazards and risks associated with green jobs. To our knowledge, our review is the first such overview of the potential occupational health issues that we may encounter in the Singapore workforce.

In the USA, employers are required by the Occupational Safety and Health Act (OSHA) to abide by the safety and health standards and regulations that are issued by OSHA or by a state that has a state plan approved by OSHA.[39] The General Duty Clause, which mandates that employers give their workers a workplace free from recognised hazards likely to result in death or significant physical harm, can be enforced by OSHA in the absence of an OSHA standard. NIOSH leads a national initiative called 'Prevention through Design'.[41] It is key concept for all industries, in particular for emerging industries. Employers are advised to set up a system wherein design engineers and safety and health experts collaborate to 'design out risks at source' during the product design process. The concept of 'design for safety' is also not new in Singapore. The Workplace Safety and Health (WSH) (Design for Safety) Regulations 2015 regulates the safe planning and construction of new buildings.[42] Figure 1 shows one of the suggested frameworks proposed by NIOSH.[43] It demonstrates the interaction of both old and new hazards with the challenges presented by emerging technologies and new adaptations of work practices in green jobs. The framework has succinctly summarised key approaches to addressing each of these four categories: known existing hazards in traditional jobs, new hazards emerging in traditional jobs, old hazards manifesting in green jobs, and new hazards arising from green jobs.

In the European Union (EU), EU-OSHA has conducted a comprehensive foresight study that examines the future development of green jobs and the potential OSH challenges that may arise.[44] Numerous potential future scenarios have been identified, considering the various economic and social

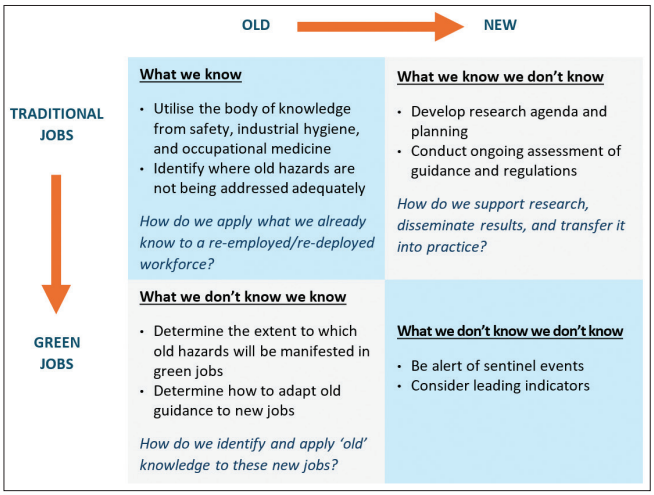

Figure 1: The National Institute for Occupational Safety and Health Proposed Framework to Approach Occupational Hazards in Green Jobs.

conditions and advancements in green technologies. The intention is to raise awareness of possible OSH hazards in this field to equip EU policymakers with the means to shape the workplaces of the future and to ensure the safety and well-being of Europe's labour force.

Given the wide range of hazards and occupational health issues that green jobs may present, the push for a green economy should be augmented by a comprehensive OSH support system to mitigate the new and emerging risks. Occupational medicine practitioners are crucial in this ecosystem and should work alongside regulators and businesses to advise on health and safety matters related to green jobs. By synthesising the Total WSH framework[45] and the WSH 2028 Report,[46] we propose the following measures to enable this endeavour:

1. Foster a pervasive culture of prioritising safety and health, starting from top management.
2. Integrate OSH with green benchmarks. Align business interests with WSH goals by incorporating safety performance into business decisions.
3. Identify occupational risks and manage them at the outset. Risk assessment and risk management should be present at the design phase and life cycle analysis of the novel technology or new process, including a participatory approach from the workers involved.
4. Encourage stakeholders' dialogue and participation of policymakers, employers and trade unions in policymaking and governance.
5. Conduct targeted baseline and periodic medical surveillance and check-ups based on the hazards the workers are exposed to. Expand efforts to prevent occupational diseases, particularly those emerging from new green technologies and materials. This includes regular health screenings and monitoring for new types of occupational hazards.
6. Provide training and retraining to ensure that employers and workers are not only competent in new roles or job tasks, but also understand the associated risks and controls.

7. Implement an incident reporting system to identify trends in workplace incidents to facilitate more timely interventions.
8. Enforce OSH quality standards. Extend WSH oversight to contractors and suppliers throughout the entire supply chain. This ensures that safety standards are maintained consistently across all levels of operations.
9. Take reference from international bodies and adopt relevant standards (i.e. for biological and environmental monitoring).
10. Conduct horizon scanning and monitoring for new hazards arising from the introduction of new technologies and processes. Establishing a WSH innovation and technology network to mobilise research institutions, technology companies and experts will enable Singapore to develop a WSH technology roadmap that will identify and implement emerging technologies to address WSH challenges.

Singapore can focus on the abovementioned key recommendations, which are aligned with the three pillars of WSH 2028, namely, Strengthen WSH Ownership, Enhance Focus on Workplace Health and Promote Technology-Enabled WSH. However, formulating OSH guidelines specifically for green jobs in Singapore and their eventual implementation present several challenges. A major challenge arises from potential conflicts between the pursuit of green objectives and OSH, with the former often taking priority. Time pressure, exacerbated by political and economic forces, may also contribute to OSH being overlooked in the adoption of green measures.

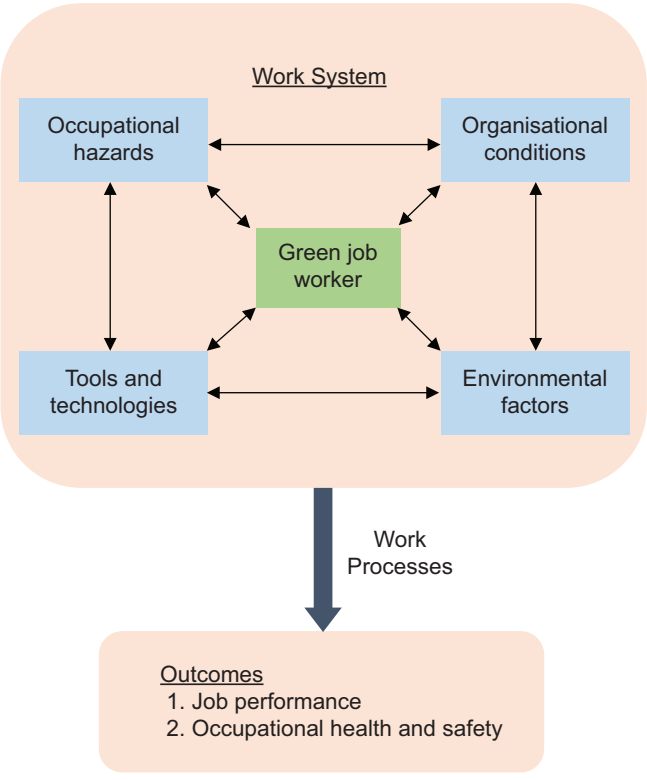

Figure 2: Systems Engineering Initiative for Patient Safety model.

Green jobs encompass a wide range of industries and activities. When attending to patients in the clinic, it is good practice to ask about their occupational history and take extra time to identify any occupational hazards, especially for those in green industries, that may warrant closer clinical scrutiny regarding the impact on their health.

Innovative technologies and processes utilised by green jobs may not be familiar to OSH professionals or regulators. Throughout their entire lifecycle, rapid technological advancements and novel materials must be closely monitored for any potential OSH risks, especially those with long-latency health effects. This necessitates constant research and cooperation between regulatory agencies and industry stakeholders to comprehensively assess any potential OSH implications. Hence, we also propose a fundamental reorientation of the approach towards occupational health assessment, given the multi-hazard and multidimensional nature of working in various sectors of the green economy. The Systems Engineering Initiative for Patient Safety (SEIPS) model [Figure 2] is a useful reference to rethink this paradigm shift.[47] A human factor-based model used in health care, SEIPS is traditionally used for root cause analyses of patient safety incidents, but has also been recently adapted to critically evaluate measures to minimise the risk of intra-hospital transmission and protect frontline healthcare workers against occupational coronavirus disease 2019 infection.[48] However, we recognise that SEIPS or similar systemic approaches can be complex to implement, especially at a micro level, and may require significant resources and expertise to apply effectively. We also recognise the value of traditional methods (hazard-, process- and human factor-based) for day-to-day OHS management and specific risk assessments. For example, process-based methods provide a systematic approach to analysing risks throughout work processes, which is useful for identifying inefficiencies and potential risks in workflows. Human factor-based methods address the crucial role of human behaviour and error in workplace safety, which can lead to more effective training and ergonomic improvements. We suggest continuously evaluating and updating risk assessment methods to ensure they remain effective and relevant to evolving workplace conditions and emerging risks.

Furthermore, instead of adopting the traditional hazard-specific approach to occupational health assessment and SME, the paradigm should change to a worker-centric approach. With the worker at the centre of the work system, we can more effectively evaluate the health risks posed by multiple, interacting hazards (physical, chemical, biological, ergonomic, psychosocial), organisational conditions (rapid hiring and induction into work), tools and technologies (may be new and unfamiliar to workers) and environmental factors (e.g. working in landfills or at height such as for PV panel installation). The degree to which these work system components interact with one another determines both OSH and job performance.

Workplace risk assessment remains essential to formulating appropriate preventive measures. Our review emphasises the need for a systematic OSH assessment of any new technologies, products and processes. Future studies can also further compare and evaluate our OSH practice in relation to other countries. We understand that policy creation and analysis is a challenging process that calls for substantial evidence and thorough evaluation, and hope future reviews and studies will continue to assess OSH risks among green jobs.

CONCLUSION

The rapid expansion of the green economy may result in a skills gap, placing inexperienced individuals in processes for which they lack the necessary training and endangering their health and safety. In addition, there might be a greater push for low-skilled workers to put up with worse working conditions if the job market increasingly values specialised skills (often associated with technology, green jobs or higher education). This contributes to the growing gap between high-skilled and low-skilled workers in terms of job opportunities, wages and working conditions. Pressure from the political and economic spheres may cause OSH issues to receive lower priority. Green jobs must benefit both the environment and the workers, in terms of their safety and health, to be genuinely sustainable. Good WSH management is vital for the health and well-being of green workers and increases their competitiveness and productivity. The medical community has a duty to ensure that what is good for the environment is also good for workers.

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Conflicts of interest

There are no conflicts of interest.

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