International Labour Organization

# Eye health and the world of work

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# Contents

# Foreword

Good vision enables and enhances almost every aspect of our daily lives. The simple act of walking from place to place is guided by the visual cues of objects, terrain and other people. Our ability to drive vehicles, to fly aircraft and transport goods safely is vision-dependent. Face-to-face communication is not conveyed through speech alone but is also interpreted by non-verbal cues, such as gestures, smiles and facial expressions. Towns and cities, economies, education systems, sports, media and many other spheres of contemporary life are organized around sight. Vision facilitates many activities of daily life, enables better educational outcomes, reduces inequality and increases work productivity (Burton et al. 2021). It is therefore vital that those who experience sight loss or problems with eye health have access to the services that can enable them to fully participate in society.

The ILO places great importance on the protection of workers' health and safety, including eye health, a fundamental objective that is enshrined in the Preamble to the ILO Constitution (1919), which notes that "the protection of the worker against sickness, disease and injury arising out of his employment" is among the improvements that are "urgently required". To this end, the ILO has developed more than 40 international labour standards focused on OSH. These standards establish minimum requirements for controlling and managing work-related risks, protecting workers across a wide range of occupations and work environments.

At its 110th Session in June 2022, after more than 100 years of existence, the International Labour Conference decided (ILO 2022d) to amend the ILO Declaration on Fundamental Principles and Rights at Work (1998) (ILO 2022c) to include "a safe and healthy working environment" as a fundamental principle and right at work. In addition, the Occupational Safety and Health Convention, 1981 (No. 155) and the Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) were designated as fundamental Conventions.

The ILO and the International Agency for the Prevention of Blindness (IAPB) have collaborated to produce this report drawing attention to healthy vision as being integral to safety and productivity at work. It is hoped that this report will raise awareness about the magnitude of the burden of sight loss in the workplace for workers, businesses and economies. It will provide recommendations to governments, employers, workers and their representatives on identifying and eliminating the risks in the workplace that can have an impact on eye health, and on promoting a safe and healthy working environment as a fundamental principle and right at work, including through eye health awareness and collaborative, multistakeholder, effective interventions to protect workers' eye health.

Joaquim Pintado Nunes

Chief

Labour Administration, Labour Inspection and Occupational Safety and Health Branch

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## About the International Agency for the Prevention of Blindness (IAPB)

IAPB is the overarching alliance for the global eye health sector, with more than 200 organisations in over 100 countries working together for a world where everyone has universal access to eye care. By 2030, we want to create a world where no one experiences unnecessary or preventable sight loss and everyone, everywhere can reach their full potential.

# Executive summary

Eyesight is an essential sense that influences most aspects of daily life, including the world of work. Its importance is highlighted by the sheer range of measures taken in many societies to enable those with permanent sight loss to navigate their surroundings and tackle everyday tasks independently.

Despite this, at least 2.2 billion people worldwide have vision impairment or blindness, with more than 1.1 billion suffering from preventable or untreated impairments. Without significant investment in preventative actions, these numbers are projected to increase, particularly in low- and middle-income countries, and in indigenous and remote communities. Even in wealthier parts of the world, many people lack access to quality eye health services. More women are affected than men and the numbers affected increase sharply with age.

In 2020, an estimated 143 million working-age individuals globally had moderate to severe vision impairment, with another 18 million experiencing blindness. The workplace specifically can also pose serious risks to eyesight, with approximately 13 million working-age people living with vision impairment of occupational origin. This places work-related vision impairments as the third largest causal factor of vision-related conditions.

Supporting workers' eye health has many benefits for governments, employers and workers, including improved worker well-being, better safety records and increased productivity. It has the potential to transform eye health in the workplace and consequently make a critical contribution to social justice overall. Conversely, a failure to address workers' eye health can lead to economic burdens for all, as it estimated that the annual global productivity loss due to vision impairment is at least US$411 billion in purchasing power parity.

Occupational safety and health (OSH), which encompasses workers' eye health, is a subject of importance to several Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, including SDGs 3, 8 and 16. Accordingly, UN General Assembly resolution 75/310, "Vision for Everyone: accelerating action to achieve the Sustainable Development Goals", recognizes the contribution that eye health can make towards the achievement of more than half of the SDGs.

At its 110th Session in June 2022, in its resolution on the inclusion of a safe and healthy working environment in the ILO's framework of fundamental principles and rights at work, the International Labour Conference recognized the Occupational Safety and Health Convention, 1981 (No. 155) and the Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) as fundamental Conventions. The resolution also noted that "a safe and healthy working environment requires the active participation of governments, employers and workers through a system of defined rights, responsibilities and duties, as well as through social dialogue and cooperation."

Conventions Nos 155 and 187 work together to provide a framework for the continual improvement of safe and healthy working environments. They cover all branches of economic activity and all workers, serving as the foundation for the safety and health measures provided in other specific OSH instruments. However, to fully meet the requirements of these Conventions, ILO Member States need to take into account the provisions of the full body of more than 40 international labour standards that specifically deal with OSH, which provide minimum standards for the control and management of work-related

risks and the protection of workers across a wide range of occupations and situations in which work takes place.

Together, these Conventions establish the general principles for a systems approach to OSH management. Convention No. 155 calls for a coherent national OSH policy and action at the national and enterprise levels, defining the key responsibilities, duties and rights. Convention No. 187 takes a systems approach to promoting safe and healthy working environments, by focusing on the establishment of national policies, systems and programmes with a view to fostering a national preventive OSH culture. The principle of prevention is fundamental to OSH, which highlights the complementary roles of governments, employers, workers and all other stakeholder in improving safety and health at work.

These fundamental Conventions also support workers' eye health and infer that there are three key aspects to be considered in this area:

- To reduce risks to eyesight in the workplace itself.
- To ensure access to eye care services.
- To promote good eye health for all workers throughout their working lives.

Robust OSH measures are critical for reducing risks effectively through proper workplace controls. An effective OSH programme should encompass provisions that identify and assess risks to eye health; a control plan; effective communication of risks; an appropriate training and procurement process; and monitoring, inspection and incident-reporting processes to ensure continual improvement. There should be clear lines of responsibility, as well as worker participation.

Access to services is important for the promotion and prevention of eye health issues, as well as for treatment and rehabilitative interventions. In addition to reducing risks, access to services can prevent and ultimately eliminate the vast majority of vision trauma and disease caused by hazardous workplace exposures.

To promote good eye health in workers throughout their working lives, it is necessary to ensure a strong collaboration with public health players beyond the workplace whose objectives of preventing sight loss overlap. These include government agencies, medical professions, NGOs, community and international organizations active in the field of eye health, and occupational health professionals. A proactive approach in the form of eye health promotion campaigns, with key players acting in harmony, can achieve a real paradigm shift for eye health in the workplace, reducing and eliminating workplace vision impairment and loss.

These measures, when performed together and combined with a clear acknowledgement of the importance of eye health, have the potential to create a transformational change for eye health in the workplace. This in turn can realize significant benefits for both employers and workers and recognizes the workplace as being critical to contributions to social justice overall.

# 1. Introduction

> Vision is the most dominant of human senses…. During the life course, most people will experience vision impairment, even if just the need for reading glasses.
>
> Burton et al. 2021

The importance of vision is demonstrated when considering the measures that many societies have put in place for those who live with permanent sight loss, to help them participate in and navigate independently through society. These measures include walkways with raised tactile bumps, crosswalk sounds to help safe crossings at street intersections, flashing lights to warn drivers, and guide animals. Braille, a universal tactile-sense code reading system, has been in existence since the mid-1800s. In recent years, digital technologies have played a significant role in helping people with poor vision access information and engage with the world around them. These digital technologies include screen readers, text-to-speech software, magnification tools and other assistive devices that enable people to read websites, books, legal papers and other important documents. In many countries, laws have been enacted to ensure that public spaces are accessible to people with disabilities. These laws require businesses, government buildings and other public spaces to make accommodations for people with disabilities, including those with poor vision. For example, websites might need to be designed in a way that accommodates screen readers and other assistive devices.

The UN resolution entitled "Vision for Everyone: accelerating action to achieve sustainable development" highlights the fact that sight loss is associated with various social issues (UN 2021). These include the reduction of personal independence, mobility and employment opportunities, which ultimately leads to a lower quality of life. The UN resolution draws on compelling evidence from health and development research, which indicates that good eye health contributes to the achievement of many of the Sustainable Development Goals (SDGs). For instance, addressing poor eye health can aid in achieving not only SDG 3 on good health and well-being, but also other goals such as SDG 1 on the elimination of poverty, SDG 2 on zero hunger and SDG 4 on quality education. Poverty can be both the cause and the result of poor eye health, as it hinders access to health services, which means that improving eye health can lead to increased household income and educational attainment, thereby reducing poverty and hunger; it can also lead to decent work and economic growth, contributing to the achievement of SDG 8. It is worth noting that low- and middle-income countries are particularly affected, with 90 per cent of unaddressed sight loss occurring in these nations.

Solutions and treatments for most common eye health problems are often straightforward, available and immediate (Burton et al. 2021). Presbyopia, in particular, is easily treatable with prescription spectacles. There is therefore a huge opportunity for addressing eye health in the workplace, in order to unlock not just workplace productivity, but also global progress on multiple agendas. Yet, at least 2.2 billion people worldwide have a vision impairment or blindness, of whom at least 1 billion have a vision impairment that could have been prevented or has yet to be addressed, according to World Health Organization (WHO) data (WHO 2019). Among the working-age population[1] in 2020, about 143 million people were living with moderate and severe vision impairment, and about 18 million people were blind (Burton et al. 2021). It is estimated that around 13 million people in the working-age population globally live with vision impairment of occupational origin.

1 The working-age population is commonly defined as persons aged 15 years and older, but this varies from country to country.

Every worker has the right to a safe and healthy working environment, as enshrined in the 2022 ILO Declaration on Fundamental Principles and Rights at Work (ILO 2022c). Realizing this right requires the active participation of governments, employers and workers through a system of defined rights, responsibilities and duties, as well as through social dialogue and cooperation. International labour standards require governments to "in consultation with the most representative organizations of employers and workers", formulate, implement and periodically review a coherent national policy on occupational safety, occupational health and the working environment (Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187)). Likewise, employers are accountable for and have a duty to organize measures designed to ensure occupational safety and health (OSH) in the workplace, as far as is practically reasonable, in consultation with workers and their representatives (Occupational Safety and Health Convention, 1981 (No. 155)). A vital tool to ensure a safe and healthy working environment, including the prevention and protection of workers from occupational hazards to the eye, is an efficient and comprehensive OSH management system, which comprises effective hazard identification, risk assessment and preventive measures implemented according to the Hierarchy of Controls, and guarantees workers' participation in the management of OSH.

Occupational hazards to the eye include mechanical trauma from flying particles, like wood and metal fines, non-ionizing radiation (NIR), for example solar radiation and lasers, chemical and biological splashes, and ergonomic factors. However, many eye conditions, which can impact a worker's ability to perform tasks, are caused by non-occupational factors, such as ageing and exposure to solar or NIR outside the workplace; nevertheless, they pose OSH risks. To protect from all hazards and promote workers' eye health, a collaborative approach is required with overlap and integration of the administration and functions of OSH and public health. In this approach, government organizations – such as ministries of labour and health, employers and workers and their representatives, standards organizations, ophthalmology and OSH professional associations – should consolidate their efforts for the promotion of eye health. This collaboration should occur at national, subnational and individual enterprise levels, as provided by Convention No. 187 and the Occupational Health Services Convention, 1985 (No. 161) and further articulated by the WHO's Eye Care In Health Systems Guide for Action (WHO 2022). Collaborative preventive interventions require the involvement of world of work actors, as they can include: health promotion campaigns that identify the highest-risk industries; vision screening in workplaces; occupational injury and disease prevention; worker information and training; first aid before sending injured workers for medical treatment; and compensation and rehabilitation (Burton et al. 2021; IOHA n.d.; ILO 1998).

This approach of coordinating care across related sectors aims to prevent eye diseases and injuries by galvanizing the collaboration of all parties that have responsibilities, knowledge, skills, abilities and vested interests in preserving and improving eyesight. Preventing ill eye health will ultimately facilitate many daily life activities, enable better educational outcomes, reduce inequality and increase work productivity (Burton et al. 2021).

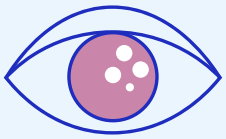
© Photo by Graham Coates submitted to the IAPB World Sight Day Photo Competition

# 2. Global burden of vision impairment

Globally, of the 2.2 billion people who have a vision impairment or blindness, at least 1 billion have a vision impairment that could have been prevented or has yet to be addressed, according to WHO data (WHO 2019). This equates to about 25 and 14 per cent of the 2020 world population, respectively (UN 2019). Without a significant investment in prevention, this number could rise to 1.7 billion people by 2050. There are a number of common eye conditions which can result in moderate and severe vision impairment or blindness (Figure 1), with the primary causes including (Burton et al. 2021):

- uncorrected refractive errors (161 million people)
- cataract (100 million people)
- age-related macular degeneration (8 million people)
- glaucoma (8 million people)
- diabetic retinopathy (4 million people)

**Figure 1: Common eye conditions that can cause vision impairment**



## Age-related macular degradation

Damage to the central part of the retina responsible for detailed vision leads to dark patches, shadows or distortion of the central vision. The risk of developing macular degeneration increases with age.

## Cataract

Cloudiness in the lens of the eye, leading to increasingly blurred vision. The risk of developing cataracts increases with age.

## Corneal opacity

A group of conditions causing the cornea to become scarred or cloudy. Opacity typically results from injury, infection or vitamin A deficiency in children.

## Diabetic retinopathy

Damage to blood vessels in the retina, which become leaky or blocked. Vision loss most commonly occurs due to swelling in the central part of the retina, which can lead to vision impairment. Abnormal blood vessels can also grow from the retina, which can bleed or cause scarring of the retina and blindness.

## Glaucoma

Progressive damage to the optic nerve. Initially, loss of vision occurs in the periphery and can progress to severe vision impairment (this is known as open angle glaucoma, the most common type).

## Refractive error

Due to the abnormal shape or length of the eyeball, light does not focus on the retina, resulting in blurred vision. There are several types of refractive error, the most common of which are myopia: difficulty seeing distant objects (near-sightedness); and presbyopia: difficulty seeing objects at near distance with increasing age (i.e., after 40 years of age).

## Trachoma

Caused by a bacterial infection. After many years of repeated infections, the eyelashes can turn inwards (known as trichiasis), which can lead to corneal scarring and, in some cases, blindness.

## 2.1. Societal burden of vision impairment

The impairment of vision from all causes, including blindness, causes severe economic losses and impedes the realization of certain SDGs. The Lancet Commission found, based on conservative assessments, that the prevalence figures for 2020 suggest an annual global productivity loss due to vision impairment of approximately US$ 411 billion in purchasing power parity (Burton et al. 2021). The cost to tackle unaddressed refractive errors and cataracts alone is estimated at US$ 24.8 billion (WHO 2019).

The incidence of vision impairment is heavily influenced by the level of economic development. The prevalence of presenting visual acuity in many low- and middle-income regions is estimated to be four times higher than in high-income regions (Bourne et al. 2017). Similarly, the combined density of ophthalmologists varies from a median of 1 per million population in low-income countries to 221 per million population in high-income countries (Burton et al. 2021).

Even in high-income countries in which the majority of the population can access eye care with relative ease, the most marginalized groups, such as indigenous people, may not be able to access the same care with the same ease. These countries include the United States (Burton et al. 2021) and Australia, where the availability of good access to quality cataract surgery for indigenous Australians is half that of non-indigenous Australians (Keel et al. 2018).

The geographic determinants of distance, altitude, terrain and weather patterns can be formidable obstacles for improving equitable access to vision care. In many low- and middle-income countries, eye care services are only provided in secondary or tertiary hospitals based in urban centres, that are inaccessible to large swathes of the population, especially the most vulnerable (IAPB 2022). Rural populations also face greater barriers to access eye care due to poor transportation infrastructure, road quality and travel time, among other factors (Liu et al. 2018).

Of the 1.1 billion people with vision impairment, 609 million are female (55 per cent), compared to 497 million males. In industrialized countries, this is largely because women live longer than men and many eye conditions such as cataract, presbyopia, glaucoma and age-related macular degeneration are associated with increasing age. However, in non-industrialized settings, where cataracts are responsible for the most blindness, this gender gap arises from the fact that women are not able to access services with the same frequency as men, due to various socio-economic and cultural factors. These findings have important implications for ensuring that women are employed and maintain their productivity, income and positions in society into middle and pre-retirement chronological age.

Adults aged 50 and older account for 73 per cent of people with vision loss (IAPB 2020). For workplace health, natural eye diseases, such as presbyopia, age-related macular degeneration and glaucoma, have an increasingly important impact, as they directly impact workers' ability to work safely and accurately during middle and later stages of work life.

# 2.2. Work-related burden of vision impairment

## Key facts and figures

- Approximately 13 million working age people live with a vision impairment of occupational origin.
- An estimated 3.5 million occupational eye injuries occur yearly.
- Workers with a vision impairment are 30.2 per cent less likely to be in employment, compared to those without.

## Global data on the work-related burden

Estimates based on national labour force and household surveys (ILO 2023a), that combined more than 610,000 participants, indicate that about 13 million people in the global working-age population live with a vision impairment of occupational origin. This is the consequence of the 3.5 million estimated occupational eye injuries (about 1 per cent of all non-fatal occupational injuries) that occur every year (ILO 2021). Among the global working-age population in 2020 (defined as 15 years or older), about 143 million were living with moderate and severe vision impairment and about 18 million people were blind (Burton et al. 2021; WHO 2019).

## National data on the work-related burden

National data on the prevalence of work-related vision impairment is, in general, very limited:

- The Afghanistan Living Conditions Survey in 2017 estimated, based on about 160,000 survey participants, that more than 2.5 per cent of the vision impairment cases among the working-age population were due to work accidents. This is the equivalent of a rate of 44 and 41 cases per 10,000 for male and female workers respectively.
- The 2021 national labour force survey of Ethiopia, based on the participation of almost 175,000 respondents, estimated that more than 10 per cent of the cases of vision impairment were caused by occupational diseases, while almost 6 per cent were due to occupational accidents. Thus, occupational injuries and diseases combined were responsible for 108 and 82 cases per 10,000 female and male workers, respectively.
- In Lesotho in 2019, more than 8 per cent of the reported vision difficulty were work-related (injuries and disease combined), based on a national labour force survey with more than 40,000 participants. This is the equivalent of a rate of 110 and 75 cases per 10,000 male and female workers, respectively.
- More than 9 per cent of the working-age population lives with vision impairment in Zimbabwe, based on a labour force survey with about 40,000 participants. About 6 per cent of the vision impairments reported were linked to work-related accidents. This is the equivalent of a rate of 117 and 53 cases per 10,000 male and female workers, respectively.
- Based on the Survey of Occupational Injuries and Illnesses conducted by the United States Bureau of Labour Statistics in 2020, the rate of non-fatal injuries and illness per 10,000 full-time workers involving eyes in the total private sector was 1.6 (US BLS 2020). This is a significant reduction of almost 70 per cent, compared with the 4.9 non-fatal injuries and illness per 10,000 workers reported in 2001.

## Unemployment figures

Among the working-age population, the overall relative reduction in employment for those with vision impairment was about 30.2 per cent globally, compared to workers without vision impairment (Marques et al. 2021). Available national studies support these findings, whilst also highlighting important gender inequalities. The Ethiopian survey reported that 63 per cent of both male and female workers with a vision impairment of occupational origin were not employed in the labour force. Similarly, more than 50 per cent of male workers with work-related vision impairment were found to lack employment opportunities in both Lesotho and Zimbabwe, with this number reaching a staggering 83 per cent in Afghanistan. The economic burden of female workers is even more sizeable: 75 per cent of females with work-related vision difficulties were not employed in Lesotho's workforce, while in Zimbabwe this figure was 81 per cent. In Afghanistan, only 5 per cent of females with occupational vision impairments remained an active part of the labour force.

## Sectoral differences

As demonstrated above, the incidence of occupational eye injuries varies widely from country to country. Moreover, there are also considerable differences between sectors. In the United States, the three most hazardous industries, agriculture, manufacturing and construction, exhibited significantly higher rates compared to the national average, at 7.7, 3.1 and 3 per 10,000 full-time workers, respectively. Furthermore, although the overall rate of non-fatal eye injuries and illness improved by 70 per cent between 2001 and 2020, improvements in the agricultural sector specifically were only around 30 per cent for the same time period.

In Ethiopia, the highest incidence of eye-related occupational injuries was in manufacturing, with 139 cases per 10,000 workers, followed by construction and non-market services (public administration; community, social and other services and activities) with 65.7 and 58 per 10,000 workers, respectively. Agriculture was ranked relatively low, with 32.5 cases per 10,000 workers. The three most affected occupations were craft and related trades workers, plant and machine operators and assemblers, and technicians and associate professionals, with 152, 103 and 87 cases per 10,000 workers, respectively.

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# 3. Sight loss is not inevitable: Protecting the right to workers' eye health

Despite the staggering impact of vision impairment on society, over 90 per cent of vision impairment cases are either preventable or treatable through existing, highly cost-effective interventions (Burton et al. 2021). This underscores the importance of concerted and collaborative efforts at the global, national and workplace levels to safeguard the well-being of workers. A comprehensive national OSH system is central to all preventative actions. The main components of a national level OSH system are outlined in Figure 2 and explained in further detail below.

**Figure 2: Key components of a national OSH system**

**Regulatory frameworks**

- Fundamental OSH Conventions Nos 155 and 187
- Other international labour standards related to OSH and eye health
- Technical standards/guidelines from other bodies

**Competent OSH authorities**

- Authority at the national level responsible for OSH
- Responsible for the national OSH policy and programme
- Participation in tripartitie national councils

**Rights, duties, responsibilities of employers and workers**

- Employer responsibilities include: taking protective measures to minimize workplace risks and providing information and training on OSH to workers
- Worker rights include: removing themselves from dangerous situations
- Worker duties include: reporting dangerous situations to supervisors and following OSH procedures

**Medical care, compensation and rehabilitation for occupational accidents and diseases**

- If an injury or disease occurs, workers are entitled to curative services, compensation or rehabilitation
- Insurance benefits include healthcare and compensations
- ILO's 2010 List of Occupational Diseases can be used by countries as a model for building, developing, strengthening and harmonizing national recording and notification systems

## 3.1. Regulatory framework

Experience has progressively shown that hazards can be managed by preventive and protective measures, and consequently public authorities have developed OSH regulations with the aim of preventing occupational accidents and diseases. International labour standards are legal instruments crafted by the ILO's constituents (governments, employers and workers) at the International Labour Conference, which sets standards on world of work issues. The ILO has adopted more than 40 international labour standards in the field of OSH to guide governments in setting national laws and regulations, including those applicable at the workplace. National laws and regulations, in turn, define the obligations that should be acted upon by employers and stakeholders, and lay down rights relating to OSH.

The Convention Nos. 155 and 187 are now recognized as fundamental Conventions. All ILO Member States, even if they have not ratified these Conventions, have an obligation arising from the very fact of membership in the ILO to respect, promote and realize, in good faith and in accordance with the ILO Constitution, the principles concerning the fundamental right to a safe and healthy working environment that are enshrined in these Conventions. They contain provisions of general scope, covering all branches of activity and all workers, regardless of the type of hazard. They also serve as the basis for the safety and health measures provided in other specific OSH instruments, such as the Radiation Protection Convention,1960 (No. 115), part of which protects the eyes of workers from visible and invisible light (non-ionizing radiation), or ILO guidelines such as those on the use of lasers in the workplace (IRPA and ILO 1993).

In addition to ILO standards, other formalized technical standards or guidelines are written to make decisions regarding safe levels of exposure to various chemical, biological, and physical workplace hazards. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) researches and publishes standards to protect people and the environment against adverse effects of NIR, including the hazards of lasers, ultraviolet (UV), and infrared (IR) and visible light (ICNIRP 2013). The American Conference of Governmental Industrial Hygienists (ACGIH) is a scientific organization at the national level (United States). It publishes well-researched threshold limit values for occupational exposure to physical, chemical and biological agents, as well as the documentation related to the setting of those protective values, for example, with respect to common workplace exposures to light and near-infrared radiation. Standards organizations such as the ICNIRP are frequent collaborators of the WHO and the ILO.

## 3.2. Competent OSH authorities

Laws and regulations also lay down the functions and responsibilities of the public and private institutions through which national action has to be organized. One of the key components of OSH administration at the national level is the authority (or authorities) competent in OSH. They should be designated by the government and made known to all. This competent authority should assume the primary responsibility for the national OSH policy, and OSH national programme, as described in Conventions Nos 155 and 187.

Convention No. 155 states that the formulation of a national OSH policy "shall indicate the respective functions and responsibilities ... of public authorities, employers, workers and others" (see Art. 6). It also outlines the key functions of the national authority on OSH. It is common for multiple government institutions and bodies, such as the ministry of labour, ministry of health and sectoral ministries, such as those of agriculture or mining, to share responsibilities in OSH or related areas. Social security institutions, such as those dealing with pensions and workers' compensation, are often involved as well. All of these entities work towards the shared objective of safeguarding populations from acute and chronic diseases, debilitating injuries and premature death. To achieve these goals, it is necessary to develop relationships and mechanisms to synergize and harmonize activities, in order to ensure the overall dignity, well-being, economic security, and safety and health of workers. The leading OSH authority should also ensure that appropriate consultations are held with representative employers' and workers' organizations. The most common form of coordination is the participation of all government departments involved in OSH in tripartite national councils.

## 3.3. Rights, duties and responsibilities of employers and workers

Convention No. 155 also defines the responsibilities of employers and describes the rights and roles of workers and their representatives. Convention No. 187 mentions "a system of defined rights, responsibilities and duties" as part of "a national preventative safety and health culture" (see Art. 1(d)).

In dealing with the OSH risks, the following general duties and responsibilities of employers are applicable.

- Employers have the overall responsibility to ensure that all practicable preventive and protective measures are taken to minimize occupational risks.
- Employers are responsible for providing adequate information, comprehensive instruction and necessary training on OSH, consulting workers on OSH aspects related to their work, and notifying the labour inspectorate of cases of occupational diseases.
- If no other preventive measure can be put in place, employers are required to provide workers with adequate protective clothing and personal protective equipment (PPE) and appropriate training on their use, in order to prevent, so far as is reasonably practicable, the risk of adverse effects on health;

The following general rights, duties and responsibilities of workers apply.

- Workers have the right to remove themselves from a work situation when they have reasonable justification to believe that it presents an imminent and serious danger to their life and health, and the right to be protected against undue consequences if they do so.
- Workers have the duty to report immediately to their supervisor any situations representing imminent and serious danger, and the right to refuse to return to a work situation in which such danger persists.
- Workers have the duty to follow established OSH procedures, avoid the exposure of others to health and safety risks, and participate in training provided by the employer.

The following general OSH principles also apply.

- OSH measures shall not require workers to incur a financial cost.
- Cooperation between employers and workers and/or their representatives at the workplace shall be an essential element of workplace-related prevention measures, such as through workers' safety delegates, safety and health committees, and collaboration in providing information and training.

## 3.4. Medical care, compensation and rehabilitation for occupational accidents and diseases

In line with the Employment Injury Benefits Convention, 1964 (No. 121), if prevention fails and an occupational accident or disease occurs, affected workers are entitled to curative services, compensation and/or rehabilitation. An employment injury scheme providing appropriate assistance and cash benefits should therefore be in place. The organization of insurance, that is, the recognition of rights and administration of benefits in the event of an occupational accident or disease, vary from country to country, according to their national circumstances. Many entities and bodies are often involved and play complementary roles, such as public bodies, employers' associations or private insurance companies.

The insurance benefits that workers receive in the event of an occupational accident or disease include healthcare and cash benefits. Healthcare benefits provide workers with the necessary medical care and rehabilitation so that they can return to work. Cash benefits include subsidies in cases of temporary disability and compensation in the event of permanent disability or death. The family members and/or dependants of workers who died as a result of occupational injuries, diseases or exposure to an occupational hazard should also be entitled to survivors' benefits.

In most countries, the scope of insurance is determined by the legal definition of such contingencies, which deems occupational accidents to be those events that cause actual injury to the worker "an occurrence arising out of, or in the course of, work which results in fatal or non-fatal injury" (Protocol of 2002 to the Occupational Safety and Health Convention, 1981). For occupational diseases, the ILO's List of Occupational Diseases (revised 2010) can be used by countries as a model for building, developing or strengthening, and harmonizing their national systems for recording and notification, and for compensation for occupational diseases. The List includes a range of internationally recognized occupational diseases that can affect the eye, such as those caused by chemical, physical and biological agents and occupational cancer. It also has open items that allow the recognition of the occupational origin of diseases that are not specified in the list, if a link is established between exposure to risk factors arising from work activities and the disorders contracted by the worker. The ILO has published a guidance note on the diagnosis and prevention of the diseases in the List, (ILO 2022b) which serves as a useful tool for health practitioners to increase their knowledge and understanding and facilitate the diagnosis of occupational diseases.

# 4. OSH programme to protect and enhance the vision of workers

Vision is integral to safety and productivity at work. All workplaces should have a management system for protecting and enhancing the vision of workers. In line with the international labour standards like Convention Nos. 115, 155, 170, 187, Occupational Health Services Convention, 1985 (No. 161) among others and the ILO's guidelines on OSH management systems (ILO-OSH 2001) (ILO 2009) and taking into account WHO's policy on integrated people-centred eye care, the OSH programme to protect and enhance the vision of workers should be designed with these three goals in mind:

- **To prevent exposure to the hazards particular to each workplace by using the Hierarchy of Controls.**
- **To protect the existing health of workers' eyes.**
- **To provide a system to include workers' naturally occurring sight loss, including age-related vision loss, in risk assessments.**

Overall, the OSH programme to protect worker's eye health should emphasize the importance of consultation with workers and their representatives, as well as the duties, rights and responsibilities of employers, workers and their representatives in preventing eye ill health (ILO 2009). Incorporating these elements can help to promote a culture of safety, improve the effectiveness of the programme, and enhance the health and well-being of all workers in the enterprise. The disciplines and knowledge bases required to understand the particular hazards of each workplace and the vision health status of workers include:

- engineers and technicians who design workflow, the technical means of production and quality control;
- OSH professionals, for example ergonomists, in the case of adjusting computer work stations to provide safe viewing distances, and adjustments for glare and posture;
- worker representatives;
- medical and first aid departments;
- local ophthalmology departments or consultants; and
- the procurement department, which needs to have criteria for ordering equipment that meets country or international standards.

The elements of an OSH programme (ILO 2009; WorkSafeBC 2019; Anna 2011) to protect and enhance the vision of workers are shown in Figure 3, with further details provided below.

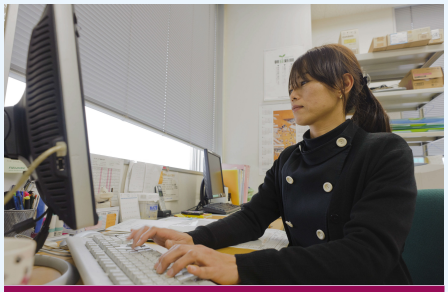
**Figure 3: Elements of an OSH programme to protect worker vision**

1. Introduction

2. Policy and planning

3. Hazard identification, risk assessment and control

4. Emergency prevention, preparedness and response



5. Procurement

6. Training and information

7. Medical surveillance

8. Record-keeping

9. Programme Evaluation and action for improvement

## 4.1. Programme introduction

The programme should start with a detailed explanation of its scope and objectives, emphasizing the need for a participatory and multidisciplinary approach and highlighting the need for consultation with workers; the duties, rights and responsibilities of employers, workers and their representatives; and collaboration with OSH and healthcare professionals, as appropriate. However, it is essential to recognize the limited capacity of microenterprises and small and medium-sized enterprises and the informal economy to implement extensive and exhaustive management systems. Accordingly, the national OSH system should include support mechanisms for a progressive improvement (Convention No. 187).

## 4.2. Policy and planning

The programme should include a policy statement that outlines the enterprise's commitment to preventing eye ill health, the means to carry out these aims, and the responsibilities of all parties involved, including workers and their representatives.

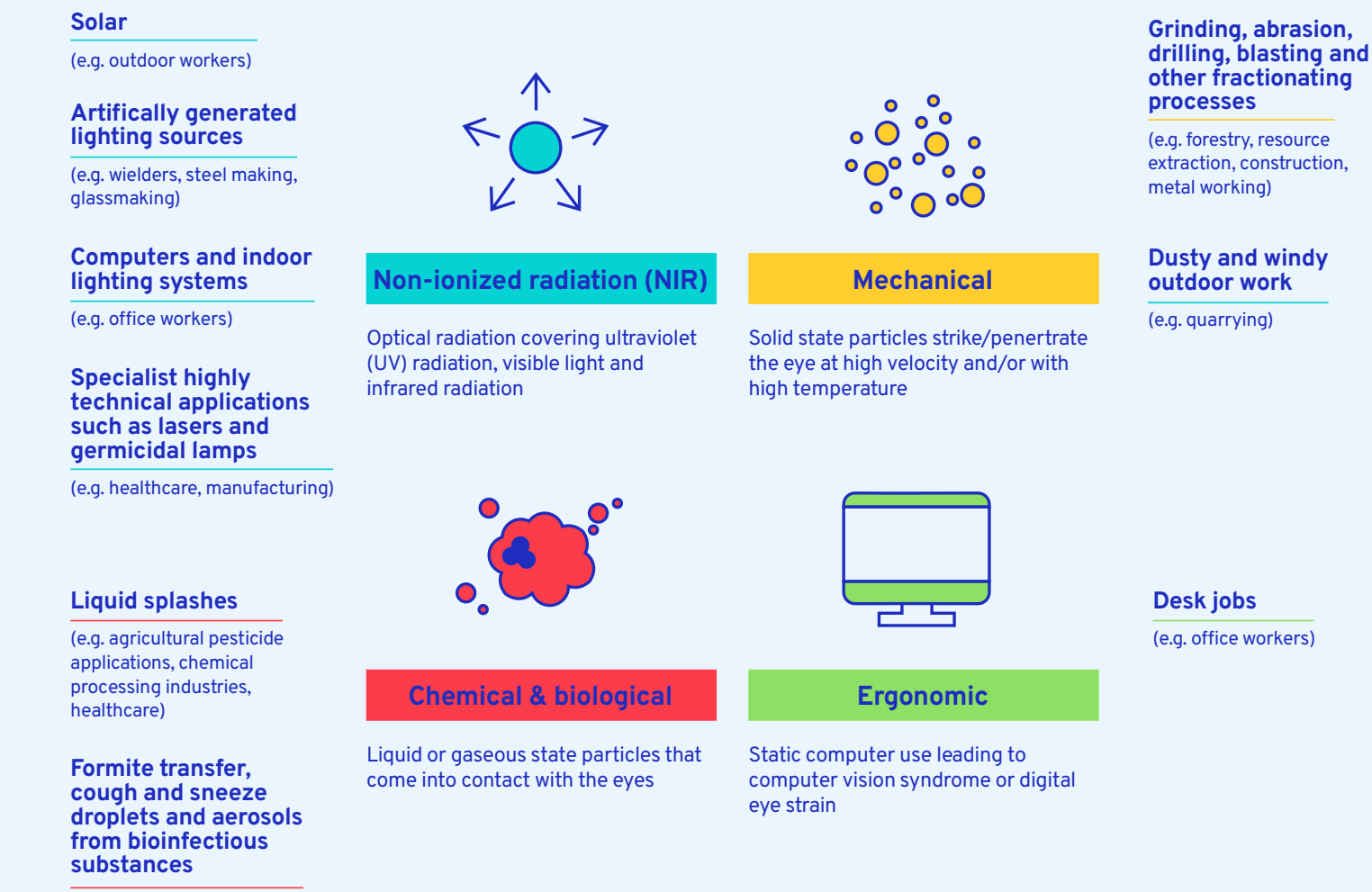
The most essential objective is to create a systemic culture of safety and health so that all parties in the workplace work together to prevent accidents, injuries, occupational diseases and fatalities (Convention No. 187, Reason 1990; ILO 2022a). The policy statement identifies the roles of the managers, supervisors, workers, workers' representatives and medical first aid teams. Management should also designate responsibilities throughout the organizational structure, such as production management, engineering and procurement, if applicable. External experts, such as ophthalmologists/optometrists and professionally certified OSH professionals, can also be consulted (ILO 2023b).

In addition, the programme should establish a plan for its implementation and monitoring that includes workers' participation and consultation, and allocates adequate resources and time frames to ensure effective implementation. Regular management meetings can review progress and strengthen the programme, in consultation with workers' representatives, based on the safety and health performance of the enterprise.

## 4.3. Hazard identification, risk assessment and control

Employers have an obligation to assess the risks of the workplace, including the dangers to vision; determine the risks of injury and disease; and put in place safe work procedures as requirements of work.

**Figure 4: Overview of occupational hazards to the eyes and sectors of exposure**

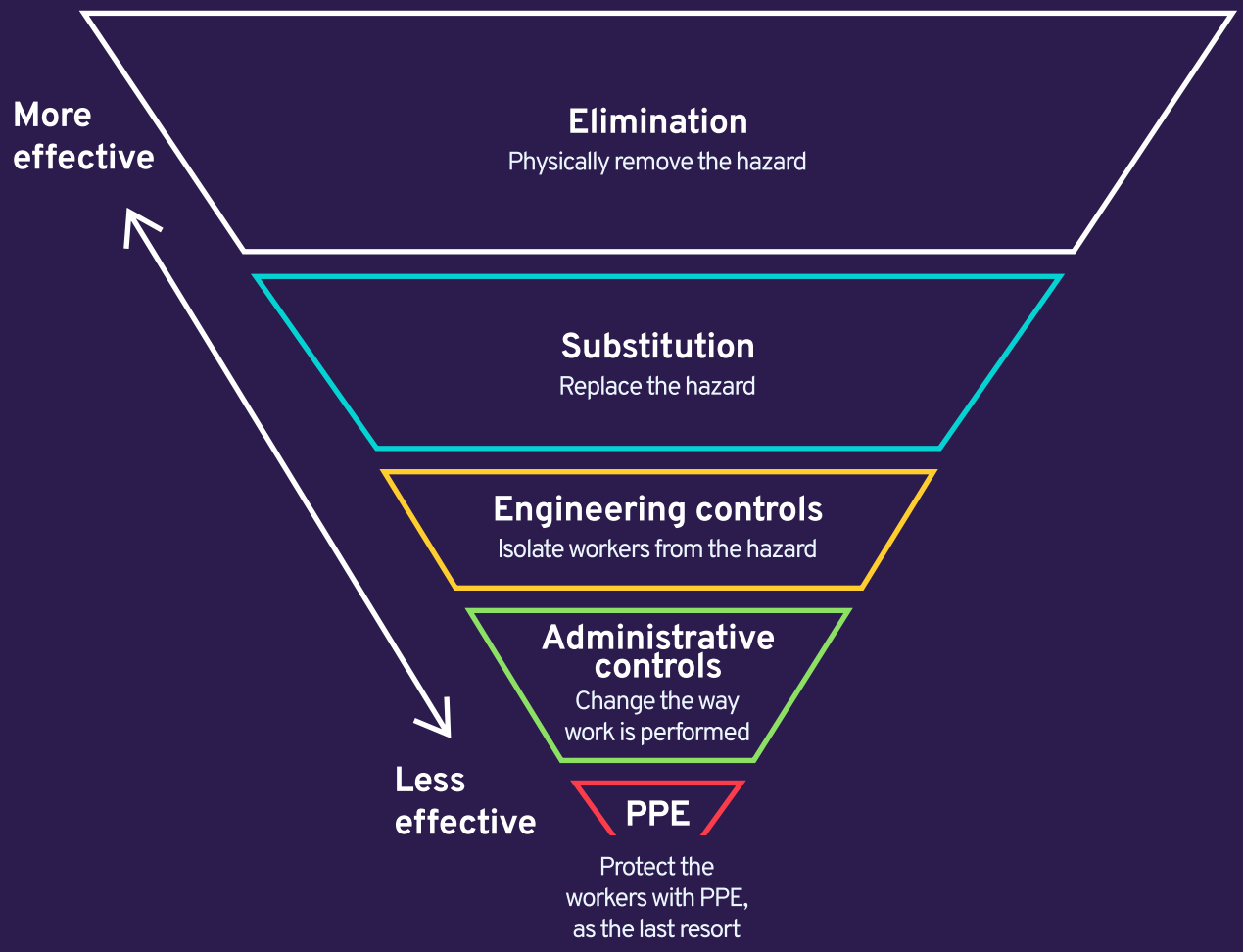



This starts with the identification of potential eye hazards in the workplace. Occupational hazards to the eyes include NIR, physical, direct mechanical trauma, chemical and biological exposures, and ergonomic hazards (Figure 4). The identification of these hazards depends on the nature of the industry, as well as the specific work environment and tasks carried out. For example, an outdoor agricultural operation will have different specific hazards than an indoor agricultural hydroponic or greenhouse operation. Workers in the outdoor agricultural operation will be exposed to solar NIR, whereas the indoor agricultural hydroponic or greenhouse operation will have various kinds of grow lights with different spectrums as hazards. Welding on outdoor construction sites and mining will contain the hazards of solar radiation, UV and visible NIR, as well as the physical hazards of high-velocity flying metal fines from grinding, arc-gouging and rock-blasting. Welding operations during indoor metal fabrication and repair will have similar hazards, but will not have the spectrums of sunlight (solar NIR). A detailed account of potential workplace eye hazards is provided in Appendix A.

When the hazards have been identified, the risks associated with them can then be assessed. Potential health outcomes can be immediate (acute) or take longer periods of time to manifest the injury or disease (chronic), and this should be considered in the risk assessment. Workers and their representatives should be consulted during the hazard identification and risk assessment processes.

Once the risks have been assessed, appropriate control measures can be determined to eliminate or minimize these risks following the Hierarchy of Controls (NIOSH 2023; Manuele 2020; Anna 2011). The Hierarchy of Controls is based on a ranking of the most effective control means to the least effective, in this order: elimination, substitution, engineering controls, administrative controls or PPE to protect employees from eye hazards (Figure 5).

**▶ Figure 5: Hierarchy of Controls - Design of the workplace to prevent accidents, injuries, fatalities and occupational diseases**




Source: United States, National Institute for Occupational Safety and Health (https://cdc.gov/niosh/topics/hierarchy/default.html).

The competent persons designated in the policy and organizing (element 1) can advise exposure control plans and safe work procedures. An exposure control plan (WorkSafeBC 2019) defines the means of eliminating or reducing risk to a level as low as is reasonably practicable for all hazards. Lowering the risk from one hazard should not increase risk from other hazards. By examining the ensemble of hazards in a workplace, including the hazards to vision, the safety and health of workers can be protected, which contributes to the overall performance of the enterprise.

Although the elimination or substitution of a hazard are the most effective control measures, they may not be possible in all cases. Well-designed engineering controls that prevent hazards at source from coming into contact with workers are often the most feasible solution.

Administrative controls include hazard and risk assessment, leading to safe work procedures, education and training in safe work procedures. Inspections and quantitative measurements of NIR form an important part of administrative controls.

Finally, in terms of protection, PPE serves as an immediate barrier to minimize exposure to hazards. However, it is important to note that PPE is considered the least effective method of protecting workers, and its efficacy relies on proper usage. While the use of PPE may be unavoidable in certain situations, such as for safeguarding against solar radiation in workplaces in which other control measures are limited, it is crucial to emphasize the necessity of using appropriate equipment, such as sunglasses, to mitigate the potential risks. An example of the Hierarchy of Controls related to different eye health hazards is shown in Figure 6.

**Figure 6: Example of the Hierarchy of Controls related to different eye health hazards**

| | | | |
|---|---|---|---|
| **More effective** | **Elimination** | Physically remove the hazard | Replace welding with adhesive bonding or fasteners. (Protection against physical hazards) |
| | **Substitution** | Replace the hazard | Replace incandescent lighting with light-emitting diodes (LEDs). (Protection against NIR) |
| | **Engineering controls** | Isolate workers from the hazard | Hand tool guards to prevent contact with moving parts, which will also deflect flying particles and fines. (Protection against mechanical hazards) |
| | **Administrative controls** | Change the way work is performed | The 20–20–20 rule, which requires workers exposed to digital eye strain to look away after every 20–minute period, at something 20 feet away, for a total of 20 seconds. (Protection against ergonomic hazards) |
| **Less effective** | **Personal protective equipment (PPE)** | Protect the worker with PPE | Goggles that seal with the skin or face shields. (Protection against biological/chemical hazards) |

Managers, production engineers, supervisors and workers should be trained to properly implement the Hierarchy of Controls. Depending on the complexity of an enterprise, competent professionals as identified in element 1 (programme development and responsibility) can then apply the Hierarchy of Controls and plan written safe work procedures. Guidance on how to apply the Hierarchy of Controls is provided in Appendix B.

Considerations for controls should meet the country's national OSH regulations, in alignment with international labour standards and guidelines, which define engineered design specifications for equipment, including machinery, equipment that generates NIR and items such as protective barriers, interlocking devices and PPE. The exposure limits for various forms of NIR should also be respected, according to the relevant legal jurisdiction, recommendations and guidelines of international and national standards associations, such as those of the ICNIRP (ICNIRP 2013), the ACGIH (ACGIH 2023) and the American National Standards Institute (ANSI)/International Safety Equipment Association (ISEA) (ANSI/ISEA 2020).

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## 4.4. Emergency prevention, preparedness and response

Emergency prevention, preparedness and response arrangements should be established and maintained. These arrangements should identify the potential for accidents and emergency situations and address the prevention of OSH risks associated with them, based on the size and nature of activity of the organization.

Such arrangements should address first aid and medical assistance, firefighting and evacuation of all people at the worksite, and should provide relevant information and training to all members of the organization, at all levels, including through regular exercises in emergency prevention, preparedness and response procedures.

They can include the treatment of common injuries, such as foreign objects in the eyes, or interim treatments for welding arc flash. They should also include the performance of life-saving and life-stabilization techniques in the event of major trauma.

In contrast, small and medium-sized enterprises are likely to only have first aid facilities and will need to refer major injuries and the diagnosis of occupational diseases to local clinics and regional hospitals. Artisanal workshops, retail/wholesale and office operations will typically have to refer all medical aid and follow-up cases to local clinics and regional hospitals.

## 4.5. Procurement

The success of a programme to protect vision depends in great part on the criteria that the procurement department uses to purchase machinery, engineering controls, PPE and ophthalmic and other services. These services may include contracted training, the maintenance of equipment, and the calibration/measuring of NIR exposure levels to ensure they meet regulations and standards.

The procurement process should not act in isolation from the other elements of the OSH management system. Specifications according to relevant standards must be included in purchase orders and contracts. The objective is to ensure that machinery, equipment and processes that are part of the procurement process are safe and without risk to health. The purpose of the procurement process should be to seek out the equipment and services that reduce hazards to as low as is reasonably practicable.

## 4.6. Information and training

The OSH programme should be complemented by the provision of regular training to workers on the risks associated with eye hazards and how to prevent them; the use of PPE, as appropriate; and emergency procedures in the event of an eye injury or exposure to hazardous materials. Supervisors are required to ensure that safe work procedures are followed and to set up a joint employer–worker OSH programme. Worker participation and feedback during training and information sessions should be encouraged. To protect their vision, supervisors, managers and workers therefore need to be aware of the specific hazards of their work, as well as the safe work procedures within the scope of their duties and responsibilities.

There are a number of requirements information and training (ANSI/ASSP 2019), including:

- providing training in a language and technical vocabulary that workers understand;
- giving training prior to starting a new task;
- ensuring that trainers are competent and have pedagogical skills;
- testing of what workers have learned, including mentoring, experience, certification, licensing and performance assessments via observation;
- delivering training on compensated time, with the schedule aligned with the workers' normal work schedule, as far as is reasonably practicable; and
- taking account of workers who have special needs such as disabilities, language or cultural differences.

## 4.7. Medical surveillance

Given the significance of vision for ensuring safety and productivity, it is crucial for all workplaces to give consideration to establishing a medical surveillance programme that monitors workers' eye health and detects early signs of occupational eye diseases or disorders, as far as is reasonably practicable (Ehrlich et al. 2021). Such a programme should provide access to regular eye exams and consultation with medical professionals in order to monitor and manage any occupational hazards, and should ensure that workers are informed of the results of their medical surveillance. Workers and their representatives should be consulted in the design and implementation of the medical surveillance programme.

Occupational injuries and diseases of the eyes are typically addressed by workers' compensation programmes. However, in addition to these programmes, there is a complementary model – that of occupational health services. This model focuses on primary prevention and involves regular eye examinations that lead to appropriate treatment, including the provision of eyewear and medical interventions. An eye health medical monitoring programme covers workers who are subject to age-related vision loss, such as presbyopia and macular degeneration. When ophthalmic services, either from public or private sources, are engaged in an integrated manner in the workplace, substantial benefits can accrue to both workers and the enterprise. They also serve as an educational component of the OSH programme, which then translates into take-home knowledge for workers' families and the communities in which they live. They also contribute to the stability of the ageing workforce, the continuity of wages and the increased productivity of the enterprise.

Not all enterprises have occupational health services established at the workplace level to take care of pre-employment and return-to-work medical exams. Convention No. 161 and its accompanying Occupational Health Services Recommendation, 1985 (No. 171) envisage occupational health services as multidisciplinary and comprehensive and, although essentially preventive, include the provision of first aid and emergency treatment. Occupational health services can be adjusted to national and local needs and can be supported by external providers or organized by primary healthcare units, especially in small-scale enterprises or for providing services to the self-employed.

## 4.8. Record-keeping

Each level in the Hierarchy of Controls should be carefully documented for periodic review and to establish a "track record" that demonstrates diligence in applying the OSH programme. It should also be the responsibility of management to maintain detailed records of the hazards identified, the risks assessed and the control measures implemented, whilst ensuring that workers and their representatives have access to these records. There should also be records of worker's training and medical surveillance results. Any medical information should be kept confidential and only accessible to healthcare staff under confidentiality agreements (ILO 1998).

These records should be used to evaluate the effectiveness of the programme and make any necessary improvements, and workers' participation in this evaluation process should be ensured.

## 4.9. Programme evaluation and action for improvement

The elements of an OSH programme overlap and should be coordinated at many points in a feedback reinforcement cycle in order to ensure its effectiveness in preventing eye-related health issues at the workplace. It is essential for management to conduct regular evaluations. These periodic reviews should identify opportunities for improvement and ensure that the programme is meeting its objectives, including through consultation with workers and their representatives in the decision-making process. Moreover, such reviews should result in adjustments, as needed, to address any identified weaknesses or new hazards. Furthermore, fostering a culture of safety and continual improvement necessitates that employees at all levels feel empowered to report risks and incidents, including near misses, without fear of retaliation or discrimination (Reason 1997).

Important lessons for the continual improvement of an OSH programme for the protection of vision can be learned from investigating all pertinent OSH events, including near misses. It is important to recognize that regardless of how sophisticated a system approach to vision protection may be, human fallibility means that errors are inevitable. When errors occur, it is crucial to acknowledge them and take corrective actions (Reason 1990). Inspections and incident investigations serve as the means of identifying system weaknesses and implementing necessary corrections in order to ensure the ongoing improvement of the programme and to prevent any recurrences. The incident investigation process should define what needs to be investigated, time frames for an investigation, who should participate, and how recommendations to prevent recurrence should be generated and communicated. The team investigating incidents should be composed of a range of competent persons, with the mandate to examine the chain of events and determine systemic corrective actions.

It is often presumed that incident investigations are simple matters of determining “what happened” and jumping to an “obvious” conclusion. The “what happened” single final action may then be mistaken for the cause of the incident. In reality, incident causation is the result of a chain of events involving the OSH system, which includes human actions on many levels (Reason 1990).

For example, consider an incident in which a metal grinder does not put on eyewear during a brief touch-up job and gets a particle lodged in one of her eyes. A thorough investigation would seek answers to a series of “why” questions and might find that more than one worker was ignoring PPE due to production demands, a lack of training or that the supplied PPE was uncomfortable and subject to lens fogging.

These findings could in turn indicate that there was a procurement problem as the right PPE had not been purchased; that there was a weak level of supervision; and that senior management had not adopted a system of education, training and inspections to identify a system safety problem. When a single action by a single individual is seen in the context of a chain of events in incident causation, the incident may be seen to have arisen from a series of failures. Whether openly stated or not, such conclusions inevitably result in increased confidence in the safety system. Individuals will be much more likely to report even near misses in an open culture of continuous improvements, in which there is no fear of retaliation or discrimination.

# 5. Interdisciplinary collaboration to control workplace hazards: protecting and enhancing the vision of workers

OSH and public health contain overlapping domains. Both have the goals of preserving existing vision and preventing ocular trauma and exposure to damaging levels of NIR, chemicals, biological agents and ergonomic risks. However, governance structures for the two disciplines are typically vested in different ministries. Furthermore, the functions of the two disciplines are also different. Public Health systems typically treat workers once they have been seriously affected by a work process or have developed an occupational disease. On the other hand, OSH's role is to prevent the injuries and diseases from happening at the workplace. Nevertheless, at the systems level, these distinctions of governance and functions can inhibit the "continuum of promotive, preventive, treatment and rehabilitative interventions against the spectrum of eye conditions" (Burton et al. 2021).

Given the significant burden of preventable sight loss, it becomes necessary to enhance synergies/collaboration between public health and OSH disciplines into coordinated initiatives, with the involvement of employers and workers' organizations, in order to reduce the burden of sight loss in the workplace. The medical treatment of workplace injuries and occupational diseases is the natural realm of public and private health services – government agencies that set policy and fund the health infrastructure, as well as local and regional hospitals and affiliated clinics, public and private. The natural causes of vision reduction can be remediated by workplace vision treatment programmes, in collaboration with the medical professions.

The medical practitioners who treat eye injuries and preserve and enhance vision with spectacles and medical procedures such as cataract surgery are general physicians, ophthalmologists, optometrists, opticians, surgeons and allied medical professions. Many NGOs and international or community-level organizations bring eye services to communities – and in some cases directly to the workplace. They include the WHO, the International Agency for the Prevention of Blindness, the International Council of Ophthalmology and the World Council of Optometry, each of which are interconnected with national affiliates.

OSH is a well-recognized medical speciality. It is represented by several NGOs such as the International Commission on Occupational Health, which was founded in 1906, the International Occupational Hygiene Association and the International Ergonomics Association, which have close working relationships with the ILO and the WHO.

Similarly, the professionals who are dedicated to protecting the eyes of workers from the physical, chemical, biological and NIR hazards are known as OSH professionals. Subdivisions within the OSH professions include occupational hygienists, safety engineers, radiation specialists (ionizing and non-ionizing), ergonomists and allied technicians.

OSH professions are represented internationally by the International Occupational Hygiene Association and the International Network of Safety & Health Professional Organisations among others. Many OSH professionals hold certifications, having gone through rigorous accreditation processes by organizations such as the Board for Global Environmental, Health and Safety Credentialing (ILO 2023b).

Each of the above-mentioned organizations have their own levels of professional knowledge and insights to identify the conditions for sight loss, as well as methods for the preservation of vision. OSH professionals are trained in the art and science of protecting workers through the Hierarchy of Controls. Primary prevention (Hierarchy of Controls), combined with secondary prevention (medical interventions based on workplace OSH programmes), can prevent, through the target of elimination, the vast majority of vision trauma and disease caused by hazardous workplace exposures. National and local ministries of health, together with the ophthalmic professions (including hospital ophthalmic departments), can identify rates of acute, repeat and chronic injuries, as well as treatment modes. The different ministries responsible for labour and for workers' compensation should have the capacity to provide specialized assistance to employers and to enforce OSH legislation. All such ministries should have the capacity to identify populations and workers with eye trauma and disease, which depends on the efficiencies of their reporting and record-keeping systems. Community organizations have the capacity to identify, for example, gig or informal workplaces that may not be on the radar of the reporting mechanisms of official organizations. Community organizations are also well positioned to encourage workers, and even their families, to be informed and participate in OSH initiatives.


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## ▶ Workplace example: A construction site

Consider a construction site at which workers are exposed to various hazards, including flying debris, chemicals and intense light sources. The site has implemented an OSH management system, with a specific focus on eye safety.
By taking the following steps, the OSH management system can prevent eye-related accidents.

### 1. Hazard assessment

The OSH management system begins with a comprehensive assessment of the workplace to identify potential eye hazards. This includes evaluating the tasks, equipment, materials and work areas that may pose a risk to workers' eyes. Hazards may include airborne particles, chemical splashes, welding arcs or bright lights.

### 2. Engineering controls

Once eye hazards are identified, the OSH management system promotes the implementation of engineering controls to eliminate or minimize the risks. For example, the use of machine guards, protective barriers or local exhaust ventilation systems can help prevent debris or chemicals from reaching workers' eyes.a

### 3. PPE

The OSH management system ensures that appropriate PPE is provided and used correctly. In the case of eye protection, workers are provided with safety glasses, goggles, face shields or welding helmets, depending on the specific hazards present. The OSH management system includes guidelines on selecting the right type of eye protection and emphasizes the importance of wearing it consistently in hazardous areas.

### 4. Training and education

The OSH management system includes comprehensive training programmes to educate workers about eye hazards, the proper use of eye protection, and emergency procedures. Workers are trained on recognizing potential eye hazards, understanding the limitations and proper maintenance of eye protection and responding to eye-related incidents.

### 5. Regular inspections

The OSH management system establishes a schedule for regular inspections of eye protection equipment and work areas. Inspections help ensure that eye protection is in good condition, fits properly and is being used consistently. Any issues or deficiencies identified during inspections are promptly addressed.

### 6. Reporting and investigation

The OSH management system encourages workers to report near misses, incidents or any concerns related to eye safety. When an eye-related accident occurs, a thorough investigation is conducted to determine the root causes and identify preventive measures. This helps improve safety procedures and prevent similar incidents from happening in the future.

### 7. Continuous improvement

An effective OSH management system emphasizes continuous improvement. It encourages the ongoing evaluation of eye safety measures, incorporating feedback from workers and staying updated with best practices and advancements in eye protection technology. Regular reviews and updates to the system ensure that it remains effective and aligned with changing workplace conditions.

By implementing and maintaining an OSH management system that is tailored to eye safety, the construction site can identify and mitigate eye hazards, provide appropriate eye protection, train workers effectively, conduct regular inspections, promote incident reporting and investigation, and continuously improve eye safety practices. This proactive approach significantly reduces the risk of eye-related accidents, protects workers' vision and fosters a safer work environment.

# 6. A paradigm shift using the model of health promotion campaigns

The Lancet Global Health Commission on Global Eye Health (Burton et al. 2021) found that eye health needs to be clearly framed as a development issue, which in turn will have substantial and immediate benefits for prosperity and social progress. Opportunities have been missed, however, because the eye health sector has traditionally focused on treatment. Health promotion campaigns and prevention strategies are underused.

Health promotion campaigns and strategies (WHO 2016) are well known, well documented and broad-based concepts that can identify and reduce the causes and impacts of sight loss in workplaces. They are also well tested methodologies for improving health outcomes.

A broad range of parties have mutual interests for ensuring that workers can see clearly to perform their tasks, and that the occupational causes of sight loss are identified, prevented and eliminated. The parties that can form multidisciplinary and cross-jurisdiction teams include:

- national and local ministries of health and labour
- ophthalmic professional associations and private vision care providers
- ophthalmic hospitals, ophthalmology & optometry practices and clinics, either public or private;
- employers' and workers' organizations
- individual employers and workers
- OSH professionals (occupational hygienists and safety engineers)
- community organizations
- health insurance companies
- primary and community healthcare organizations and service providers
- non-communicable disease organizations and providers
- glasses suppliers and retail outlets

By convening multistakeholder initiatives, with the leadership of governmental institutions, into multidisciplinary eyesight preservation health promotion campaigns, greater and even synergistic results can be achieved than by individual actions.

The Lancet Commission found multiple examples of the provision of spectacles and cataract-screening either free of charge or at low cost in the form of a health promotion campaign (Burton et al. 2021). These services, and timely appropriate access to follow-on services and products, have often resulted in increased household income and reduced gender inequality.

## Case study: Direct ophthalmic intervention to treat mild age-related presbyopia and cataracts in tea pickers in India

An excellent example of direct ophthalmic intervention in the workplace is the action-research study to treat presbyopia and cataracts for tea pickers in the Assam region of north-eastern India (Reddy et al. 2018). Study participants were primarily women, with a mean age of 47 years. Most of them had modest presbyopia and none wore glasses. The income of tea pickers is determined by the weight they pick. After evaluating their vision through standard testing, glasses were offered free of charge to correct presbyopia. A substantial productivity increase of 20 per cent was achieved in this rural cohort by providing glasses at low cost and with a high intervention uptake. While the study design and action intervention of eyeglasses was limited to presbyopia, workers with cataracts were referred for free surgery and those with other conditions were referred to a local eye hospital. The Assam tea workers study is a sterling example of a health promotion campaign, using the coordinated action of OSH and public health systems, with the shared aim of protecting workers' vision.

From an OSH perspective, it is noteworthy, however, that solar UV NIR was not considered as a causal or contributing factor for sight loss in the study, either qualitatively or quantitatively. The study also did not address whether the eyeglasses or other PPE, such as broad-brimmed hats or other face/head coverings, would be protective from solar UV exposure in this high-sunlight area, or whether workers would use them as an adjunct to preserve vision and prevent further loss. The discussion of UV radiation in the context of the Assam tea pickers intervention highlights the added value of multidisciplinary participation in determining the range of risk factors in outdoor workplace studies.

## Case study: Vision and the safety of commercial and transportation drivers in Ghana

Professional driving includes transportation of goods by small and large trucks/lorries and the transportation of people in buses and taxis. Often it involves the transportation of dangerous goods and bulk materials. Crashes of commercial vehicles can have serious consequences beyond the life and limb of drivers since the heavy loads, velocity and momentum, and the dangerous goods they can carry, influence severity of crashes. Worldwide road traffic injuries caused 1.35 million deaths in 2016; they are the leading global cause of death for children and young adults between the ages of 5 and 29 years. A study of commercial vehicle drivers in Ghana by Ovenseri-Ogom and Adolfo determined that more than 12 per cent of commercial drivers did not have the minimum visual acuity required for driving (Ovenseri-Ogomo and Adofo 2011). There was also poor utilization of refractive error services, with the barriers to uptake of eye care services largely due to drivers not being aware of visual deficiencies. This suggests that awareness raising through health promotion campaigns is important for ensuring that drivers maintain the minimum visual requirements to prevent accidents and crashes. These could include placing Portable Roadside Eye Examination Stations along major transport hubs, with drivers referred for corrective lenses and other treatments after examination.

# 7. Conclusion

Workplaces can pose serious risks to eye health, as is evidenced by the millions of workers living with vision impairments of occupational origin. Without a significant investment in preventative actions, there numbers are projected to rise, especially in low- and middle-income countries. Aside from the devastating impacts on individuals and their families, the burden on society continues to be considerable, especially when considering the lack of employment opportunities available for those with vision impairments. Supporting workers' eye health has many benefits for governments, employers and workers, including improved worker well-being, better safety records and increased productivity.

The inclusion of a safe and healthy workplace in the ILO's framework of fundamental principles and rights at work presents an opportunity for change in the area of workplace eye health. The many eye injuries and diseases caused by workplace hazards, including NIR, biological, mechanical, chemical and ergonomic risks, are entirely avoidable with the implementation of comprehensive OSH systems, with protective actions taken at both national and workplace levels. Fundamental OSH Conventions Nos 155 and 187, alongside more than 40 other international labour standards related to OSH, provide a framework for the continual improvement of safe and health working environments.

At the enterprise level, an effective OSH programme to protect eye health is essential for eliminating risks effectively through proper workplace controls. This programme should include risk assessment, a control plan, effective communication of risks, appropriate training and procurement processes, as well as monitoring, inspection and incident reporting. Clear lines of responsibility, as well as worker participation, are key, in order to promote a culture of safety, improve the effectiveness of the programme, and enhance the health and well-being of all workers in the enterprise.

Timely access to appropriate eye care services has the potential to diagnose, treat and ultimately prevent the vast majority of vision-related illnesses caused by trauma and disease, attributable to hazardous workplace exposures. These services can also provide a vehicle for health promotion campaigns and preventative strategies, which are underutilized, yet well known for improving eye health outcomes in the workplace.

Transformative change will only be achieved, however, with multistakeholder collaborations between government agencies, medical professions, NGOs, community and international organizations active in the field of eye health, and occupational health professionals. It is through these synergist partnerships that significant improvements to workplace eye health will be realized, benefiting workers and employers, and contributing to advancing social justice.

# Appendix A: Workplace eye hazards

Hazards to the eyes and vision are found in almost all indoors and outdoors workplaces, and in every sector of the primary, secondary and tertiary economy. Since vision protection has a direct impact on productivity, workplaces should have well considered and carefully thought-out programmes, which enable workers to complete work tasks accurately and safely, and maintain work–life dignity.

NIR, physical, chemical, biological and ergonomic hazards are the main workplace exposures leading to vision loss and impairment. These hazards are explained in detail in this section.

## NIR exposure

NIR comes from a wide range of visible and invisible light sources, including “non-coherent” and “coherent” (laser) sources. The OSH literature typically categorizes these exposures as “physical” in nature (ACGIH 2023). Exposure agents are as follows:

### Solar NIR

- Found in both visible and invisible light spectrums as UV and IR radiation.
- All outdoor workers will be exposed, including those in agriculture, forestry, construction, fisheries, garbage collection/recycling, and outdoor tourism and recreation.
- Intensity of exposure is multifactorial, depending on hours of sunlight per year and intensity of sunlight.
- Factors determining intensity include latitude, longitude, altitude and weather.
- Glare factors occur when working on or close to water bodies, snow and ice, and atmospheric ozone depletion zones.
- Health outcomes include conjunctivitis and photoretinitis.

### Artificially generated lighting sources

- Includes visual sources and NIR in the visible and invisible spectrums (UV and IR).
- High-hazard occupations are found in welding, steel and other metal melting, casting/foundry trades and glassmaking operations.
- Intensity of exposure can be acute, for example for stick welders who work in very close proximity to the welding flash arc, or for people passing by welding operations.
- Health outcomes include photokeratitis, photoconjunctivitis, photophthalmia (welder›s flash) and keratoconjunctivitis.

## NIR generated from computers and indoor lighting systems

- It is generally low hazard in offices, wholesale-retail operations and healthcare settings.
- Intensity of exposure is typically low and chronic due to long hours in static positions.
- The frequency spectrum includes blue light from computer screens (which can be suppressed during night hours by automated applications). Eye fatigue is common due to long hours in static eye-distance from the computer screens.
- Health outcomes include circadian interruption, eye fatigue and dry eye.

## Specialty highly technical applications

- Includes lasers, metal halide lamps and germicidal lamps in healthcare and industrial manufacturing/processing occupations.
- Generally, these are high-hazard technologies that are engineered with barriers and automated systems to rule out direct human contact.
- Health outcomes include photokeratitis, thermal damage and photoretinitis.

### Case study: Workers' compensation for ocular injuries in Kentucky, United States

A study (McCall, Horwitz, and Taylor 2009), carried out in the US state of Kentucky, analyzed workers' compensation data for ocular injuries occurring between 1994 and 2003. There were 10,545 claims of ocular injury, representing an annual average of 6.29 claims per 10,000 workers. The highest eye injury rates were found for the helpers/labourers occupational category, and for the construction industry. Claims made by men were more than three times more frequent than those made by women, suggesting a better safety culture amongst women than men. The authors suggested, as a means of lowering ocular injuries, "increasing worker training, providing effective eye protection equipment, and developing workplace safety cultures".

Tables related to the spectrums of NIR are provided below. Table 1 summarizes common occupational exposures to NIR and hazards to the eyes. Tables 2–4 relate to the physical properties of NIR, including wavelengths and skin penetration.

Visual, UV and IR optical radiation bands are also called "non-coherent", because their spectrums cover a wide range. The human eye detects the spectrums of visual light as shades of different colours and contrasts. It is well-known that both underlit (dark) and overlit (bright) work areas, as well as those with high-glare, compromise safety and productivity.

The eye does not respond equally to all NIR wavelengths. Both the UV and IR spectrums are not detectable by the human eye, yet brief intense and chronic exposure can damage the eyes. For example, a welder whose eyes are not protected with a face shield and a UV-resistant filter can be temporarily blinded by the intense visual light of striking the arc. The brief exposure to unseen UV-C and UV-B can also result in photochemical damage felt 2 to 12 hours after exposure, persisting for up to 48 hours, and perceived as intense pain, often expressed as "sand in the eyes".

Both the UV and IR NIR are subdivided into A, B and C ranges. Table 1 defines the wavelength bandwidths for UV, visual and IR (Anna 2011). The visible light range lies between the UV and IR spectrums.

**▶ Table 1: Common occupational exposures to NIR and hazards to the eyes**

| Occupational groups | Source of NIR | Disease or condition | Spectral regions |
|---|---|---|---|
| Outdoor workers in: Agriculture and animal husbandry; Construction; Forestry and landscaping; Artisanal and open-pit mining; Garbage collection and reclamation (e.g., electronics); Fishing; Recreation and high altitude | • Chronic lifetime solar/ sunlight exposure | • Cataract | • Chronic lifetime solar/ sunlight exposure |
| Welders in metal fabrication, repair and maintenance; Construction; Workers and public in proximity/ adjacent to welding occupations | • Electric welding arc flash<br>• Visible light from metal inert gas and oxygen lances | • Photokeratitis<br>• Photoconjunctivitis<br>• Photophthalmia (welder's flash)<br>• Keratoconjunctivitis<br>• Photoretinitis | • UV-B and UV-C<br>• IR |
| Steel mills; Foundries; Glassmaking; Drying equipment | • High temperature luminous processes | • Thermal effects | • IR |
| Optical laboratories; Entertainment; Photo reproduction | • Arc lamps | • Thermal/photochemical damage | • UV<br>• Visible<br>• Near-IR |
| Hospitals, laboratories & dentistry; Food industry; Recent installations related to the COVID-19 pandemic | • Germicidal lamps:<br>• Low-pressure, mercury – discharge lamps | • Photokeratitis<br>• Thermal damage<br>• Photoretinitis | • UV-C<br>• Blue [visual] light |
| Printing plants; Maintenance; Integrated circuits; Manufacturing | • Metal halide<br>• UV-A lamps | • Photochemical injury | • Near-UV<br>• Visible |
| Tanning salons; Beauty salons; Fitness centres | • UV-A lamps | • Photochemical injury<br>• Photoretinitis | • UV<br>• Blue light |
| Needle trades; Industry and warehouse general lighting | • Hg-HID lamps | • Photochemical injury | • UV-A<br>• Blue light |

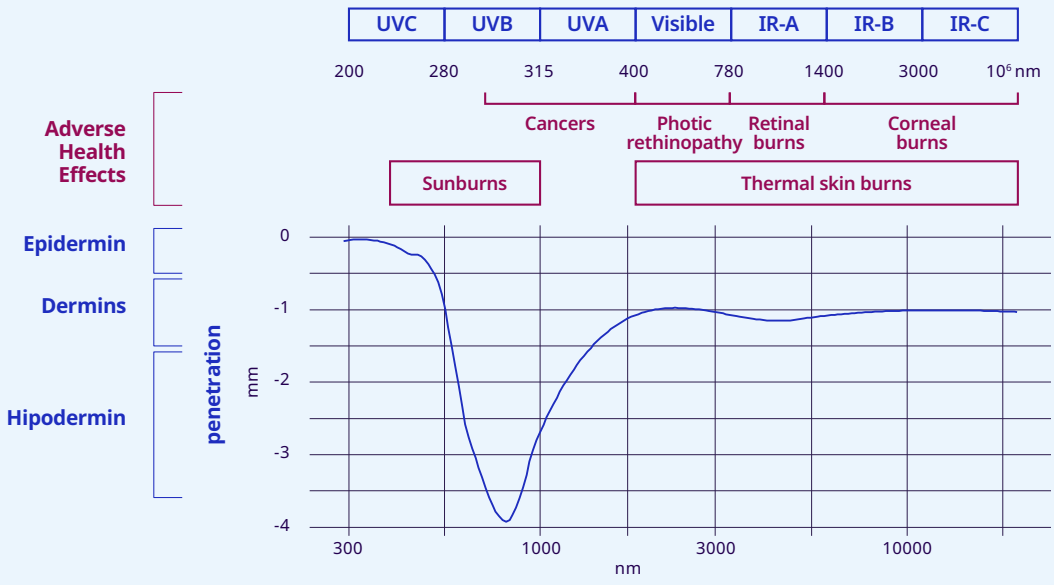
Adopted from: A Fuller, "NIR", in *The Occupational Environment: Its Evaluation, Control, and Management*, 3rd edition, ed. Daniel H. Anna (AIHA, 2011); Alberto Modenese and Fabriziomaria Gobba, "Cataract Frequency and Subtypes Involved in Workers Assessed for their Solar Radiation Exposure: A Systematic Review", *Acta Ophthalmologica* 96, No. 8 (2018): 779–788; A McKinlay et al., "ICNIRP Guidelines on Limits of Exposure to Ultraviolet Radiation of Wavelengths between 180 nm and 400 nm (Incoherent Optical Radiation)", *Health Physics* 87, No. 2 (2004):171–186; Paolo Vecchia et al, eds, *Protecting Workers from Ultraviolet Radiation*, ICNIRP, 2007; "ICNIRP Guidelines on Limits of Exposure to Incoherent Visible and Infrared Radiation", *Health Physics* 105, No. 1 (2013)):74–96; and Nicola Magnavita, "Photoretinitis: An Underestimated Occupational Injury?", *Occupational Medicine* 52, No. 4 (2002): 223–225.

**Table 2: UV/visible/IR bands and wavelengths**

| Region | Band | Wavelength (nm) |
|---|---|---|
| Ultraviolet | UV-C | 100–280 |
| | UV-B | 280–315 |
| | UV-A | 315–400 |
| Visible | | 400–770 |
| Infrared | IR-A | 770–1400 |
| | IR-B | 1400–3000 |
| | IR-C | 3000–1000000 |

Figure 7 below shows the overlap of adverse effects to the eyes from the broadband frequency spectrums of visible and infrared NIR (see also note below on the overlap of ultraviolet NIR).

**Figure 7: Potential adverse biological effects and penetration depth of visible and infrared radiation**




Source: A McKinlay et al., "ICNIRP Guidelines on Limits Of Exposure to Ultraviolet Radiation of Wavelengths between180 nm and 400 nm (Incoherent Optical Radiation)", Health Physics 87, No. 2 (2004):171–186.

In contrast to non-coherent optical radiation, lasers (light amplification by stimulated emission of radiation) are powerful coherent directional beams of singular wavelength (monochromatic) NIR. Laser spectral bands include visual, UV and IR (for a detailed description, see (IRPA and ILO 1993)).

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## Mechanical trauma

Mechanical trauma refers to solid state particles that strike or penetrate the eye at high velocity and/or with high temperature.

- High hazards examples include grinding, abrasion, drilling, blasting and other fractionating processes in primary and secondary industries.
- Primary industries include forestry and resource extraction. Secondary industries include manufacturing, metal-working, mining, construction and agricultural goods processing.
- The category also includes hazards resulting from dusty and wind-blown conditions in any outdoor work.
- Tertiary industries include office and computer work and wholesale-retail trades, in which mechanical trauma is generally of low risk.

## Chemical and biological exposures

Chemical and biological exposures refer to liquid or gaseous state particles that come into contact with the eyes.

- High-hazard examples include liquid splashes in a wide range of occupational classifications, including agricultural pesticides applications, chemical processing industries and healthcare.
- The category also includes fomite transfer, cough and sneeze droplet and aerosols from bioinfectious materials, such as the SARS-CoV-2 virus, which are known to use the eyes as infection portals (Hong et al. 2020).
- Chronic occupational exposures to certain chemicals can also be associated with neurological disorders that affect the brain's ability to process visual information.

### Case study: Occupational ocular injury in Gondar Town, Ethiopia

A study on occupational ocular injury was conducted in 2019 by the Tertiary Eye Care Training Center and by the Department of Optometry of Gondar Town Hospital in Ethiopia (Mengistu et al. 2021). It included 542 small-scale industry workers, with a 95.1 per cent response rate. The study revealed that the prevalence of occupational ocular injury among small-scale industry workers in this Ethiopian industrial town was 31.4 per cent. Iron chips were the most common agent responsible for the injury. In addition, statistically significant factors for ocular injury were: being a temporary worker, not using safety devices and lack of safety training.

## Ergonomic hazards

In computer work, people often maintain a static distance between their eyes and the screen, causing the eyes' musculature to maintain a relatively unvarying curvature. This is completely different from pre-computer times, where even shuffling paper around a desk required the eyes to constantly shift focal length, and the head and hands to constantly change positions.

Imagine holding a cup of coffee or a glass of water in your hand, with your arm extended parallel to the desk supporting the computer(s). At first, the weight of the full cup may not feel like much, but after a few moments, the static weight can become difficult to support, no matter how strong your shoulders and arm are. This same phenomenon can happen with your eyes when using digital devices for prolonged periods of time.

These static habits of computer use can lead to a group of eye- and vision-related problems, known as computer vision syndrome or digital eye strain. Symptoms may include eyestrain, headaches, blurred vision and dry eyes. These problems can be caused by poor lighting, glare on the digital screen and a static distance between the eyes and the screen. If not eliminated or controlled, they can further affect the musculoskeletal system and cause, for example, neck and shoulder pain if poor seating posture develops, which often leads to slumping of the shoulders.

### Case study: Digital eye strain among radiologists in Saudi Arabia

A study based on an online survey sent to radiologists practising at a hospital in the Eastern Province of Saudi Arabia revealed that most of the 198 participants tend to spend 7.0 hours daily reviewing medical images (Al Dandan et al. 2021). Overall, 25.3 per cent of participants take a break from work once a day only and 50.5 per cent of participants reported experiencing digital eye strain. Multivariate logistic regression analysis revealed that being female, and the practice of taking breaks only once or twice a day, were associated with higher rates of digital eye strain symptoms.

# Appendix B: Hierarchy of Controls

OSH has its own set of prevention and exposure control methods, known as the Hierarchy of Controls (NIOSH 2023; ISO 2022; Manuele 2020) This is a systematic, ranked and sequentially ordered method for eliminating or reducing the risk of hazards that produce workplace injuries, fatalities and diseases. It proceeds from the most effective controls to those that are less effective. Its objective is to eliminate hazards or reduce their risk to as low a level as is reasonably practicable. The Hierarchy of Controls is a fundamental aspect of OSH management systems (NIOSH 2023; ISO 2022; Manuele 2020; NIOSH 2014) which recognizes that the control of one hazard should not increase the risk of other hazards. From most effective to least effective, the Hierarchy of Controls is:

- elimination of hazards
- substitution of a hazard with something less hazardous
- engineering controls
- administrative controls
- PPE

A detailed description of the five different hierarchical levels, with examples, is set out below.

## Elimination

Elimination is a control that removes the hazard completely from a work process. Elimination may be difficult to implement for hazards affecting vision. For example, visible light is essential for workplace safety. For those whose vision is already impaired, and for detail work such as in the clothing needle trades, visual lighting may require enhancement. The hazard of UV NIR cannot be removed from the welding process, but it can be prevented from exposing workers through engineering controls and the correct use of PPE.

When proposing elimination as a control method, great care must be taken to prevent the introduction of other hazards. The team making recommendations should be composed of certified/registered OSH professionals, ophthalmologists, worker representatives and other experts.

## Substitution

Substitution refers to using a safer alternative to the source of the hazard. For hazards related to the eyes, substitution must be carefully considered, based on a risk analysis, as the effects of changes

in visual light may not be perceptible to the human eye and attention. Great care must be taken in using substitution as a hazard control method and attention must be paid to standards such as those of the ICNIRP (ICNIRP 2013).

An example is the replacement of incandescent lighting by light-emitting diodes (LEDs). LEDs have the potential for enhanced acuity, controlled colour spectrum and greater energy efficiency, however at the same time, can introduce unacceptable glare. In addition, variations in the power supply can lead to variations in LED intensity. LEDs can also shift colour balance to increased blue light, which can lead to photo-toxicity and effects on the circadian rhythm (ANSES 2014).

A second example is healthcare laboratories that handle infectious specimens, which require the disinfection of work surfaces, surgical and pathology instruments and ventilation systems. Properly engineered and positioned germicidal lamps will typically be more effective, more efficient and easier to use than chemical solutions, which are prone to hazards from mixing, spills and volatilization, leading to skin and respiratory systems exposures.

## Engineering controls

Engineering controls reduce or prevent hazards from coming into contact with workers. Since substitution and elimination are often difficult to implement, engineering controls typically are the most frequent consideration for preventing trauma and occupational diseases of the eyes. Well-designed engineering controls can be particularly effective, because they partially or completely remove the human factor exposure in high-hazard processes.

Engineering controls work well when they are part of the original equipment design, but also when changes in process designs are being considered. Well-designed controls are useful when they require minimal user input, operate correctly, and do not make the work process more difficult. They should also be designed with interlocks to prevent manual overrides and short-cut tampering.

Effective engineering controls use integrated safety features that shut down a hazardous process when “short-cut” attempts are made to bypass controls. An example is an enclosed process using lasers. When the cabin door is opened, the lasers automatically shut off to prevent human contact with the beam.

Despite being more expensive to purchase than PPE, engineering controls can reduce the costs of trauma and occupational diseases, while at the same time increasing productivity and lowering long-term operating costs. They require periodic maintenance however, to ensure that they are operating according to design specifications.

Three factors are especially critical when considering engineering controls:

Equipment must be installed according to manufacturers’ instructions in order to ensure that it is working to design specifications.

A scheduled preventive maintenance programme must be in place to inspect and ensure the long-term functioning of the engineering controls.

There must be a scheduled system of inspection to ensure that high NIR hazards (UV, IR, laser etc.) are controlled. This measure includes the measurement of NIR by competent certified/registered OSH professionals to ensure that there is no overexposure according to regulatory requirements.

## Examples of physical hazards to the eyes and engineering controls to address them

Physical hazards include small metal, stone, mineral fibre, and wood particles and fines flying at high velocity from processes such as:

- grinding and chipping
- welding and metal gouging
- hammering and forging
- power crushing and fragmenting
- power saw-cutting
- mining and quarrying

Engineering controls include:

- local negative-pressure ventilation exhausts, with filtering systems to capture particulate matter
- hand tool negative-pressure ventilation and filtering systems
- hand tool guards to prevent contact with moving parts, which will also deflect flying particles and fines
- water suppression
- physical barriers to protect workers at other workstations from high-velocity fines and particles
- regulation of distance between workstations, and distance between workstations and pathways involving mobile machinery and walking people

The above controls have the added benefit of protecting the respiratory system, for example from silica.

### ▶ Case study: Epidemiological characteristics of work-related ocular trauma in Chongqing, China

Chongqing is a major manufacturing area in China. A 2015 study was conducted by a hospital department of ophthalmology (Cai and Zhang 2015). Over the course of one year, 1,055 patients presented with eye injuries, with 43 per cent of them work-related. The highest proportion of occupational eye trauma was observed in the group between 36 and 45 years of age. Within the group of occupational eye trauma, female workers represented a minor fraction of those injured, at 8 per cent, suggesting a higher workplace safety consciousness in that gender group.

Metal was the most common injury cause. Workers without pre-work safety training (78 per cent) or eye protection (92 per cent) were far more likely to suffer from occupational ocular trauma than those with training and protection. There was no machine guarding involved for 75 per cent of the workers who presented with eye injuries. In addition, about 66 per cent of the injured workers were temporary workers. In this study, the authors were careful to note that the investigation was a hospital-based epidemiological research project, which did not include data on injuries and illnesses treated outside the hospital setting. It is therefore likely that the number and severity of work-related optical trauma was underreported and therefore underestimated.

## Examples of NIR hazards to the eyes and engineering controls

Illumination and lighting for visual acuity during indoor work activities in office, commercial and production activities is an important example of carefully designed engineering controls. Most indoor lighting for the illumination of work typically comes from fixed-location devices that must be installed according to manufacturers' specifications. For visual acuity, the two most important factors are the quantity of light and the quality of light designed to comfortably visualize the object in the field of view, without causing glare problems. The installation of engineering controls should consider the work surfaces, ceilings and walls that produce glare.

Computers should be equipped with glare-prevention screens and a way to reduce blue light. Some computer screen operating systems have the ability to automatically modify blue light at sunset and sunrise to prevent circadian rhythm interruption.

Another example is welding and gouging, a work process that is found indoors in large- and small-scale production activities. Welding processes can be automated, for example in the automobile production industry. Manual welding is ubiquitous indoors, but is also found outdoors in construction and small enterprise street workshops. The first principle of engineering controls for welding is to prevent welding flash containing intense visual light and UV. For automated welding processes, an effective solution is the use of complete process enclosure, including safety subsystems such as interlocks, shutters and alarms, in case the welding operation has to be directly examined during maintenance procedures, or the doors are accidentally or intentionally breached.

During manual welding, a typical, inexpensive, portable and effective solution is to use flame-retardant, heavy canvas screens. When the welding process requires outside viewing, another solution is the use of "semi-transparent" plastic. When using screens, care must be taken to ensure that they is no light leakage to nearby workstations or people passing by.

While complete containment and screens are very protective, another option is distance. According to the ACGIH, "arc lamps, welding arcs, or tungsten lamps, rarely produce a potential hazard more than 1 to 3 metres from the source, unless they have collimating optics (e.g., searchlights)" (ACGIH 2023).

Distance can be used as an effective control in outdoor situations such as construction, in which the nature of work is dynamic and moving from time to time. It can be used in fixed outdoor locations as well. Care must be exercised when using distance as a control since the distance rule can be easily breached. Physical barriers, warning signs and a well-trained workforce will be helpful in making distance an effective control, with the proviso that the control zone is regularly supervised and never violated.

# Administrative controls

Administrative controls encompass a wide variety of measures related to safe procedures and practices. They include establishing written safe work procedures, ensuring that all workers are educated and trained in these procedures, and purchasing departmental procedures for safe equipment (based on international and national standards), among many others.

An example of administrative control is the application of a healthy workplace practice, such as the 20–20–20 rule, which requires workers exposed to digital eye strain to look away after every 20–minute period at something 20 feet away for a total of 20 seconds. The rationale for this rule is that staring at a screen for a long time forces the eye muscles into a static position, much different from their normal function of focusing and refocusing on objects at varying distances. Recent evidence demonstrates that the 20–20–20 rule is an effective method for reducing digital eye strain (ISO 2022; Talens-Estarelles et al. 2022). The same rule has been routinely recommended by ophthalmic associations to relieve headaches, blurred vision and dry eyes. Ergonomists can assist in recommending proper viewing distances and chair equipment.

### ▶ Case study: Occupational eye injuries in Modena, Italy

In a highly industrialized area of Italy – Modena province – occupational eye injuries were studied during the year 2014 by a hospital department of ophthalmology (Gobba et al. 2017). Records were obtained from both the local chamber of commerce and from the Italian Compensation Authority. In Italy, all persons manifesting acute eye problems of any type are usually referred to a specialized ophthalmology department. In this case, the local ophthalmology department is open 24 hours a day, thus limiting the underestimation of eye injuries. There were 754 occupational ocular injuries reported, or 6 per cent of the total cases. Analysis of the occupational data showed a dose response curve based on age, with the 16–24 age group (presumably the least experienced workers) having the greatest annual frequency of eye injuries, and the 55–64 age group showing the lowest frequency (3.5 versus 1.8 per 1,000 workers). Women workers demonstrated a much lower rate of optical injury (13 per cent of cases) in the industrial setting. In this study, foreign workers had approximately a 50 per cent higher rate of eye injuries compared to Italian workers. The authors indicate that intervention programmes must be implemented as early as possible in the working life, with special attention being given to the highest risk groups – in this study, young people and foreign workers. It was also mentioned that when data from the ophthalmological department is combined with specific occupational information, it could be used to conduct research on eye injuries that occur in the workplace.

## ▶ PPE

The eyes are of such fragility that safety eyewear is ubiquitous and often mandatory whenever hazards are present. This is true even in circumstances in which there are well-designed engineering and administrative controls. Unless the integrity of other controls can be guaranteed during hazardous operations, safety eyewear that meets national standards will likely be obligatory.

Typical safety eyewear includes the following.

- Simple clear lenses are typically made of impact-resistant polycarbonate, often with side shields or in wrap-around style. Their purpose is to protect the eyes against:
  - flying particles and fines in all occupations; and
  - chemical and biohazardous materials splashes.
- Specialized NIR-filtering and impact resistant devices wear may be fitted into face shields for welding processes and extremely high heat-generating processes in metal foundries.
- For some industrial processes, specialized eyewear is often integrated into other PPE, such as:
  - fit-tested respirators; and
  - specialized NIR-filtering and impact resistant shields in welding and extreme high heat-generating processes in metal foundries.
- When there is exposure to chemical, blood and body fluids and other biohazardous materials, goggles that seal with the skin or face shields should be mandatory.
- Outdoor workers and transportation drivers may choose to wear sunglasses for comfort or protection against glare.
- Workers using lasers should be provided with safety glasses specifically designed for laser applications. Special care should be taken to cover the wavelength range of the light source and to use appropriate optical density lenses adequate for the laser (ANSI/ISEA 2020; ISO 2021).

PPE, however, is the least effective measure in the Hierarchy of Controls. There are multiple reasons for this. The most important reason is that PPE does not control hazards at source, as engineering controls do. For example, metal particles that are not constrained by an engineered control are free to strike and shatter protective eyewear.

The use of PPE as a safety measure depends on human factors, that is, the ability of each individual to consistently and correctly wear the equipment. For example, PPE can be uncomfortable and may impact the worker's ability to perform certain tasks/functions, as in the case of lens fogging, which impedes visual clarity. In these cases, the worker may not wear the PPE appropriately, either deliberately or by mistake.

In the case of manual welding, some workers prefer to use a hand-held shield instead of a wrap-around style hood that can also be integrated with a safety helmet. The safety issue with the hand-held shield is that the welder might not raise it quickly enough and might accidentally self-expose to arc flash.

Eye protection PPE must be part of a safety management system that relies on:

- selection according to a recognized standard such as ANSI/ISEA Z87.1–2020 (ANSI/ISEA 2020);
- identification of the type of PPE needed in relation to the hazard, for example, sunglasses that shield against UV for outdoor workers;
- fogging resistance, especially in conditions in which respirator and surgical mask requirements are in place to protect against infectious aerosols, such as the SARS-CoV-2 virus;
- training in use of the PPE, as well as supervision to ensure consistency of correct use; and
- fitting to the individual, including to ensure the comfort of the wearer and that prescription lenses meet the standards for impact resistance side shields.

The low cost of PPE may appear more attractive than the initially expensive approach of other controls, especially when safety eyewear may still be required. However, the objective is always to reduce risk to the lowest level possible through the Hierarchy of Controls. A less effective control should not be chosen until the practical applications of the preceding level or levels are exhausted (Manuele 2020).

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