

## IMPACT OF WORKPLACE LIGHTING ON EMPLOYEE SAFETY

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**Purpose:** The aim of the topic is to present the breadth of the issue of lighting in the workplace. A topic often treated marginally by employers but having a positive and negative impact on the health and safety of employees.

**Design/methodology/approach:** The article is a review of the literature on the impact of lighting on the employee, applicable, basic legal requirements, and a review of selected available statistical data on night work and work in conditions of insufficient lighting.

**Findings:** During the preparation of the article, it was found that the impact of lighting on the employee and his safety depends largely on the employer, his knowledge and commitment. Legal regulations are not precise when it comes to ensuring proper lighting for employees. Most parameters related to lighting in the workplace can be adjusted, and thanks to this there is a chance for better comfort and safety at work.

**Originality/value:** The article is a kind of recommendation for the employer - it indicates the areas that should be paid attention to, e.g. take care of employees health.

**Keywords:** workplace lighting, ergonomics, safety, shift work.

**Category of the paper:** General review.

### 1. Introduction

The working environment, according to the definition, is the conditions of the material environment (determined by physical, chemical, and biological factors) in which the work process takes place (Rozporządzenie, 2023). One of the physical factors is lighting. For the employee to be able to perform his professional work safely, effectively, and ergonomically, the employer is obliged to provide proper lighting of the workplace, adapted to legal requirements, the needs of employees and new technologies.

The subject of lighting in the workplace, as indicated in the following article, is very broad. We can talk about the typical "artificial light", thanks to which it is possible to illuminate the workspace, i.e. local lighting, but also about the one that allows for night work, i.e. you are

an indispensable piece of equipment at the workplace. Shift work is associated with a temporary lack of access to daylight, natural, without which life is difficult. But properly selected lighting parameters can help in the work (Stefani, Cajochen, 2021). Lighting is also a matter of fire safety, i.e., emergency and evacuation lighting.

## **2. Basic legal requirements for workplace lighting**

The legislator in Poland imposes several obligations on employers related to ensuring safe, hygienic, and ergonomic working conditions. Some of them concern the lighting of workstations. The relevant regulations are in the Regulation on general health and safety regulations. The employer is primarily obliged to provide electric lighting at night or during the day when natural lighting is insufficient. Both types of lighting should be available in work rooms, and additionally employees should be protected against excessive sunlight. In further items, the legislator obliges to adapt daylighting to the type of work performed, in accordance with the requirements set out in Polish Standards. Also, the illuminance in the rooms should meet the following: the ratio of the average values of the illuminance in adjacent rooms, through which internal communication takes place, should not be greater than 5 to 1. When leaving the rooms where, for technological reasons, work is carried out in darkness (e.g. optical darkrooms), conditions should be provided to allow gradual adaptation of the eyesight (Rozporządzenie..., 2003).

The requirements for the illuminance value are contained in the lighting standard PN-EN 12464-1:2022-01 Light and lighting. Workplace lighting. Part 1: Indoor workplaces. The standard also describes guidelines for other basic lighting parameters: lighting uniformity, luminance distribution in the field of visual work, glare reduction, light colors as well as flickering and stroboscopic effect (PN-EN, 2022).

When talking about employee safety, emergency and evacuation lighting should be mentioned. The first mentioned type of lighting should be installed in rooms and workplaces where, in the event of a failure, health or life hazards may occur. The requirements are defined by the Polish Standard and other legal regulations. The employer must remember that the lighting installation installed in workplaces and corridors must not expose the employee to accidents and should not generate additional hazards (Rozporządzenie..., 2003). Emergency lighting is designed to safely complete the currently implemented work processes and safely leave one's workstation in the event of a sudden lack of basic lighting (Pawlak, 2017) e.g. during fire, evacuation. So, it is logical that emergency lighting must have its own power source. In addition, the discussed type of lighting is intended to illuminate the escape route, ensure easy location of fire equipment, or enable the operation of rescue services (PN-EN, 2005, 2013). According to the standard, evaluative lighting is one of the types of emergency lighting and is designed to illuminate escape routes and is used to illuminate evacuation signs (PN-EN, 2013).

### 3. Workplace lighting and its impact on the employee

Lighting, i.e. visible radiation, is one of the basic factors of the working environment. Inappropriate - with too little or, on the contrary, with too much intensity, it is often classified as a nuisance factor, i.e. causing, for example, employee discomfort, fatigue, irritability, or a general temporary deterioration of the psychophysical condition of a person (Králiková et al., 2021). You can observe a decrease in work efficiency, less diligence, a greater number of mistakes made by the employee, which in turn may lead to an accident at work. Over time, a factor that is burdensome for health and well-being can turn into a harmful factor, which, for example, will permanently worsen the condition of eyesight. At the same time, properly selected lighting can improve employee health (Cena et al., 2019) and increase work efficiency (Juslén, Tenner, 2005), which can also improve the level of security.

The task of the employer, in the first place, is to minimize the negative effects of lighting on the employee. The most important parameter that can be easily controlled is the intensity of light. It is defined as the areal density of the luminous flux falling on a given surface. Depending on the type of work performed, the employee should be adjusted to the appropriate level. The minimum illuminance in places where work is carried out must be at least 200 lux. The more difficult the work, requiring the ability to distinguish details, or the greater the comfort of work, the higher the intensity should be (PN-EN, 2022). Also, when employing older workers, over 40, remember about better lighting (Shi, Chen, 2023). Higher intensity of lighting affects better alertness and concentration of the employee (Smolders et al., 2021), and consequently improves safety. To assess the level of intensity of the parameter in question at workstations, it is necessary to measure the average intensity in the working area and the average illuminance in the field of the immediate surroundings. The obtained results are analyzed and compared with legal requirements.

To provide employees with conditions in which their visual acuity will be better and their visual function will increase, care should be taken to ensure that the luminance of the visual field is evenly distributed. The luminance distribution is determined by the values of the reflection coefficients of the surfaces in the room or at the workstation and compared with the ranges specified in the standard. When the distribution or range of luminance is inappropriate, the phenomenon of glare may occur, i.e. a state in which there is a limited ability to recognize and a feeling of discomfort (discomfort). Glare can also arise in the face of excessive contrasts (Sawicki, Wolska, 2018). Generally, it can be said that it is too much light reaching the organ of vision. Glare is divided into three types: direct, indirect and reflective, and they are distinguished depending on the direction of the luminosity (e.g. bright objects, light sources without luminaires), in comparison with the direction of observation conducted by the employee. The effects of the glare phenomenon include, above all, general fatigue, eye strain, stress, irritability, i.e. headache, and the like can lead to an accident at work. More specifically,

due to the effects, the phenomenon of glare is divided into: disturbing, unpleasant and blinding. Disturbing is characterized by a reduction in the ability to see, in a way that is noticeable to a human, but very brief - the worker sees haze for a moment. Discomfort glare is perceived as visual discomfort, negatively affecting the concentration of the employee - the biggest problem in the workplace. The last type, i.e. blinding glare, is characterized by complete haze and the inability to distinguish, for example, objects. (ciop.pl, 2023). This is a temporary phenomenon, but the employee may not notice the threat, and a fraction of a second will lead to an accident at work.

Another factor that the employer should pay special attention to is the color of the light, referred to as the color temperature. Light sources emit warm, neutral, and cool colors. The higher the illuminance, the higher the color temperature of the light source. The warm color optically enlarges the space and creates a more friendly atmosphere (Yun et al., 2021). The cold color, in turn, stimulates and promotes concentration (Jiayi et al., 2021). The color of the light should be selected to the work performed, the room - size, color of the walls, its equipment (e.g. furniture, worktops), purpose, and above all, the hazards present at the position.

Employees, in workplaces, are also exposed to an effect called flicker. It is described as a feeling of visual instability caused by a light stimulus (Mańkowska et al., 2022). The phenomenon can be observed, among others, when the light sources are damaged or there are voltage drops in the network. Today, not very often, flicker can be noticed when pulsating discharge sources equipped with a magnetic stabilizing and ignition system, e.g. when illuminating a room with fluorescent lamps or mercury lamps. Then the stroboscopic effect appears, i.e. a phenomenon in which the employee sees the immobility of elements, objects in motion. The phenomenon is extremely dangerous (Bullough et al., 2012), because it also occurs with machines with rotating parts.

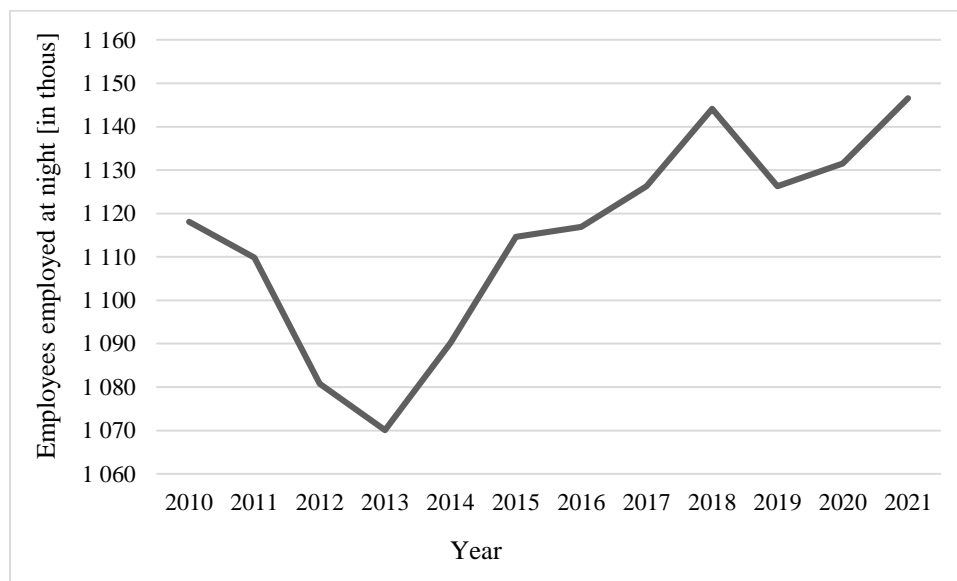
#### **4. Shift work - work at night**

Unfortunately, not all employees have the opportunity to work in conditions adapted to the biological conditions of humans. Often, due to the technological process, specificity of work or customer orders, work must be carried out at night, i.e. unnatural for humans, and this is associated with many negative health consequences (Cheng, Drake, 2019). Problems with the distribution of working time are related to the lack of daylight, forced circadian rhythm, lack of regular meals, stress, excessive mental burden, social pressure, etc. (Silva, Costa, 2023).

Shift work and night work is regulated by law. Requirements for employers have been collected in the Act - Labor Code. First of all, detailed rules regarding night work are defined by the entrepreneur in the work regulations - if the workplace is obliged to develop them and,

in the contract, concluded with the employee, or in an annex to the contract. The Act precisely defines nighttime as work covering 8 hours, between 21.00 and 7.00. In addition, if the employee's working time schedule includes at least 3 hours in each 24-hour period or at least  $\frac{1}{4}$  of the settlement period falls on nighttime, such work is considered as night work. In the case of work involving high physical or mental effort, and when the employee performs particularly dangerous work, the time of his/her work at night may not exceed 8 hours. A pregnant woman or a juvenile worker must not be employed at night (Ustawa..., 1974).

In Poland, night work, i.e. most often also shift work, is performed by over one million employees (GUS, 2022), as seen in Figure 1. Over the years 2010-2021, it seems that the number of employees working at night is increasing.



**Figure 1.** Number of employees employed in Poland at night, in 2010-2021.

Source: Own elaboration based on (GUS, 2022).

The harmfulness of night work is of great interest to scientists and is widely described in both domestic and foreign publications. It is described, among others, the impact of changing the circadian rhythm of employees (Bracci et al., 2019), the impact of the lack of natural lighting in combination with excessive artificial lighting, but also the possible positive impact of artificial light on productivity, cognitive functions of the employee (Dandan et al., 2021) and mental health (Mårtensson et al., 2015; Brown et al., 2020).

Lighting is important not only because of the vision process, but also regulates the secretion of hormones in humans, affects sleep (Bastos, Afonso, 2020) thermoregulation, level of alertness and eye-hand coordination (Żuzlewicz, Wolska, 2014). Light, especially that with a high proportion, short wavelengths, in the blue spectral range, in the evening and during night work, inhibits the secretion of melatonin, which destabilizes the circadian rhythm of employees (Hebert et al., 2002; Gaggioni, et al., 2014), but properly selected can improve employee productivity (Viola et al., 2008).

## 5. Working conditions in Poland with particular emphasis on insufficient lighting of the workplace

In Poland, the working conditions, characterizing the places where work duties are performed and the risks to which employees are exposed, are assessed annually. Statistical data is collected and compiled by the Central Statistical Office (GUS). Some of the information comes from reports sent by large employers, and some is obtained directly. Surveys carried out by the Central Statistical Office are conducted using the representative method on a deliberately selected sample and cover entities employing 10 or more people. The results obtained from the sample are generalized to the general population of entities of the national economy (employing 10 people and more). Several million employees are subject to tests every year, in 2022 it was 6.8 million people. Among this number there were 443.3 thousand. employees employed in hazardous conditions – it constitutes 6.5% of employees (GUS, 2022).

In Polish statistics, workers employed in hazardous conditions are defined as persons who may be exposed to:

- factors harmful to health related to the working environment,
- nuisance factors,
- mechanical factors related to particularly dangerous machinery.

According to the data published by the Central Statistical Office, over 260,000 people were employed in hazardous conditions related to the working environment. employees. Nearly 100,000 people are in the group of employees at risk of arduous work. people. The least numerous groups were employees exposed to mechanical factors - over 81,000. Table 1 below shows the number of employees exposed to hazards per 1000 employees. The data refer to 2022 and show general values for all branches of the economy and industrial sectors as the one with the greatest number of threats (GUS, 2022).

**Table 1.**

*Employed in conditions of risk of harmful and dangerous factors as well as arduous for health in 2022*

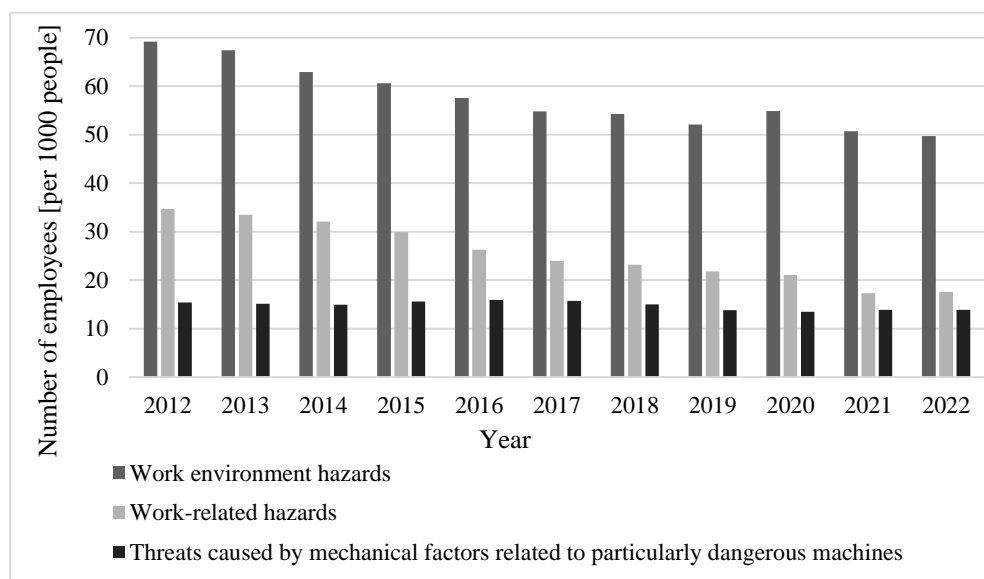
Type of threats:		Per 1000 employees in units covered by the survey	Of which in industry per 1000 employees in units covered by the survey
<b>Work environment hazards</b>		<b>49.7</b>	<b>96.9</b>
Chemical substances		2.5	4.7
including:	carcinogenic	0.9	1.7
	mutagenic	0.2	0.1
Fibrosis dusts		3.4	7
Carcinogenic dusts		4.2	9.1
Other dusts		1.5	3
Noise		26.9	57
Vibration (mechanical vibration)		2	3.1
Hot microclimate		2.9	6.2
Cold microclimate		1.6	1.9

Cont. table 1.

Ionizing radiation	0.2	0.1
Laser radiation	0.1	0.1
Ultraviolet radiation	0.4	0.8
Infrared radiation	0.4	1
Visible radiation	0.1	0.2
Electromagnetic field	0.7	0.5
Biological factors	2.9	1.9
<b>Work-related hazards</b>	<b>17.6</b>	<b>29.2</b>
Excessive physical strain	10.6	17.5
Insufficient lighting of workstations	2.5	4.5
Other	4.5	7.2
<b>Threats caused by mechanical factors related to particularly dangerous machines</b>	<b>13.9</b>	<b>24.1</b>

Source: Own study based on (GUS, 2022).

The data presented in Table 1 shows that the greatest threat in Poland is noise, especially in industrial processing. Another factor that is widely present at workplaces is carcinogenic dust. From the group of onerous factors, excessive physical workload was mentioned above all. It is estimated that insufficient lighting of the workplace occurs in 2.5 people per 1000 employed in all surveyed workplaces, including 4.5 people per 1,000 in manufacturing. Insufficient lighting of the workplace is understood as failure to meet legal requirements (GUS, 2022).



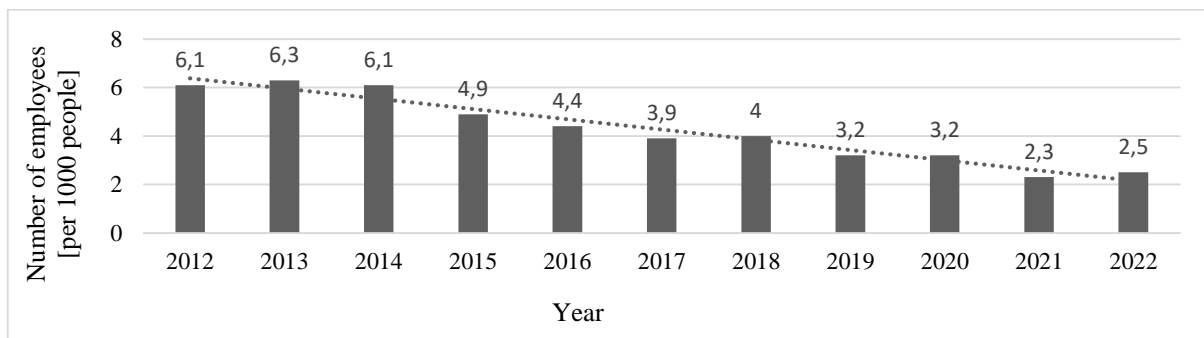
**Figure 2.** Number of employees working in hazardous conditions, in the years 2012-2022.

Source: Own elaboration based on (GUS, 2012, ..., 2022).

Working conditions in Poland are getting better and better, according to statistics. Figure 2 summarizes the number of employees exposed to hazards related to harmfulness of work, nuisance, and mechanical factors. The chart presents data for the years 2012-2022.

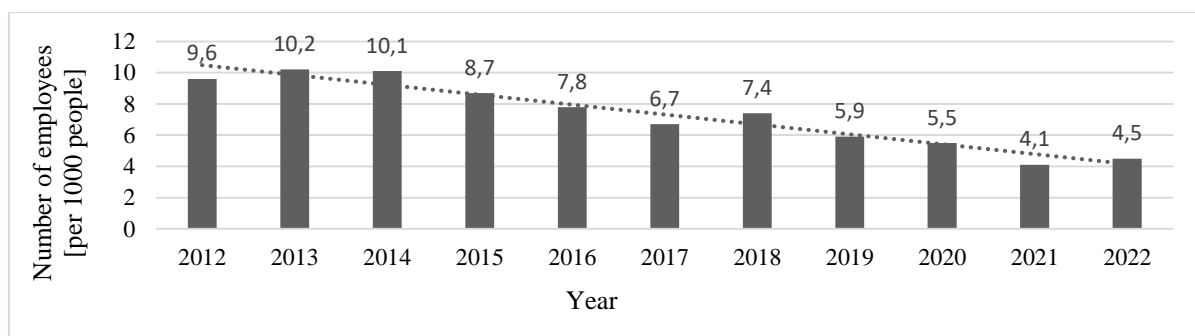
In the presented statement, these are not impressive numbers, but the very fact that the issue of lighting is monitored indicates the need to strive to improve working conditions in this area. In Poland, the relationship between improper or insufficient lighting and the causes of accidents at work is not monitored. Such a connection certainly exists.

The graph shows a clear downward trend in all three analyzed groups. The downward trend continues for employees exposed to harmful factors, such as noise, dust, microclimate, biological factors, vibrations and chemical factors. Over the last 10 years, the number of employees identified with burdensome factors at work, such as insufficient lighting at work stations, has decreased by almost 50%. Figure 3 shows the number of employees whose workplace lighting is incorrect, per 1,000 people employed in all industries in Poland, in the years 2012-2022. Figure 4 shows the number of employees at risk of improper lighting in the industrial sector, selected among all industries, also per 1,000 people employed only in industry, where working conditions are the most difficult.



**Figure 3.** Number of employees exposed to the risk of improper lighting of the workplace per 1000 employees, all industries, 2012-2022.

Source: Own study based on (GUS, 2012, ..., 2022).

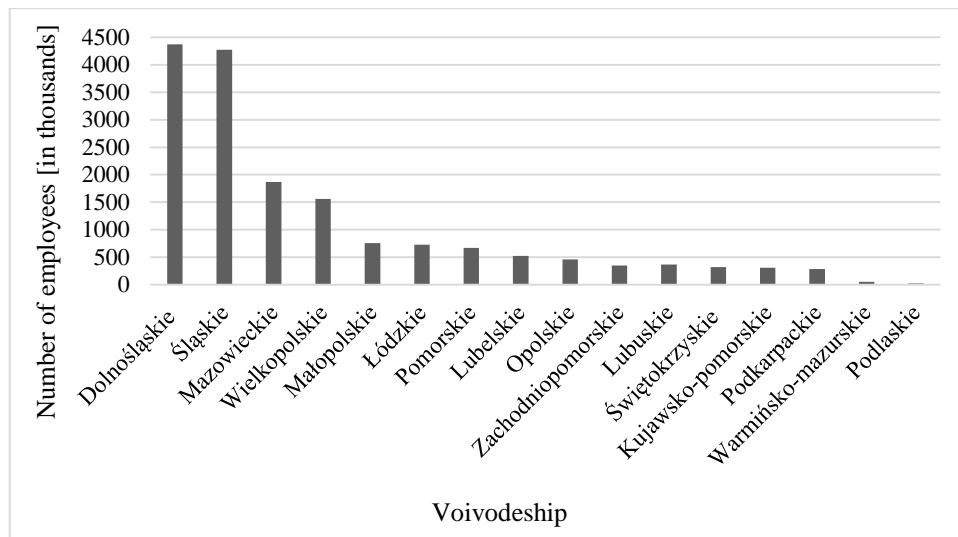


**Figure 4.** Number of employees exposed to the risk of improper lighting of the workplace per 1000 total employees employed only in the selected industry - industrial sector, 2012-2022.

Source: Own study based on (GUS, 2012, ..., 2022).

Despite the obvious improvement of working conditions, the number of employees employed with lighting that does not meet the requirements is large. In 2022, it was almost 17,000. employees. It should be mentioned here again that only companies employing 10 or more people are subject to the statistics, so the picture of the data is incomplete. About 4.5 million microfilm workers were not considered. Nevertheless, a breakdown by voivodeships in Poland was prepared for the analyzed group (Fig. 5). The largest number of people employed in positions not adapted in terms of lighting work in the dolnośląskie and śląskie Voivodeships - 4373 and 4275 thousand respectively. employees. mazowieckie and wielkopolskie voivodeships were ranked next.





**Figure 5.** Employees in conditions of risk of insufficient lighting of workplaces by voivodeships in 2022.

Source: Own study based on (GUS, 2022).

As mentioned earlier, the greatest number of hazards are identified in industry, because most people working in hazardous conditions are employed there. Continuing the topic of insufficient lighting and people employed there, attention should be paid to industrial processing; mining and quarrying; generation and supply of electricity, gas, steam, and hot water; water supply; sewage and waste management; recultivation - in 2022, about 13,000 people worked there. It is followed by construction, health care and social assistance - about 1,000 employees each, whose workplace lighting is insufficient. Over 800 people employed in the industry: transport and storage, approx. 350 - trade; vehicle repair and about 250 employees - education (GUS, 2022). Other industries are omitted due to their insignificant share in the statistics.

## 6. Summary

Despite the many signaled areas of work in which the topic of lighting appears, there are still many unresolved issues. It is worth looking at the topic of working at a computer, types of lighting and lighting fixtures, or light pollution. The topic of lighting workplaces for the elderly or the visually impaired is extremely important and up to date. For employers, the topic of lighting is difficult, often overlooked and underestimated (Sawicki, Wolska, 2022). This may be because lighting, in principle, is not subject to, for example, work environment tests or employers have the appropriate knowledge. The data presented in the article, concerning employees employed at the risk of insufficient lighting of the workplace, shows that the problem exists. There is no information available on how this risk translates into the number of

accidents at work, but it is highly probable that there must be such a relationship. Incorrectly selected lighting intensity, wrong color, light effects, or night work can adversely affect the safety of employees. But the right light intensity or the right color can increase a person's alertness, perceptiveness, and concentration, and thus improve his safety.

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