DEVELOPMENT OF SMART IOT-BASED OCCUPATIONAL HEALTH MONITORING SYSTEM: A REVIEW

[1]Jay Prakash Kumar, [2]Prof. Vivek Chandra Sagar

[1]M.Tech Student, [2]Assistant Professor, Department of Fire Technology and Safety Engineering
Vikrant University, Gwalior MP

ABSTRACT

IoT technologies are being widely utilized for enhancing occupational health and safety through monitoring of workers and workplace environments. In certain cases, conventional ways of monitoring may not be sufficient in identifying sudden changes of health and environmental risks. This review will discuss the use of IoT-based technology for smart monitoring of occupational health via the use of wearable devices, environmental sensors, wireless communication, cloud/edge computing, and artificial intelligence. Such technologies can monitor physiological and environmental variables, early detect the risks, and issue warnings on time. In addition, the challenges related to the implementation of such a system are discussed (such as the reliability of sensors, battery life, connectivity, privacy issues, security, and worker adoption). Finally, a combined framework that involves sensing, communication of data, analysis and warning will be proposed.

Keywords: *Internet of Things, Occupational Health, Worker Safety, Wearable Sensors, Smart Monitoring.*

1. INTRODUCTION

Occupational health and safety form integral parts of sustainable industrial development [1]. Construction, mining, manufacturing, agricultural, healthcare, logistics, oil and gas industries and others can pose various hazards to workers, such as overheating, noise, toxic substances, dust, physical exertion, improper position, fatigue, falls, accidents caused by machinery and others. Occupational health management should not only include identifying hazards but continuous monitoring of their effect on particular workers as well [2].

Conventionally, occupational health monitoring would consist of periodic medical checkups, manual workplace inspections, fixed environmental measurement systems, safety checklists and accident reporting [3]. However, all of the above techniques can be reactive or periodic. A person's physiological state can greatly change in the course of a working day, while workplace exposure can depend on many factors such as the exact place of work, performed activity, weather, tools used and workload. Thus, a monitoring system that focuses on either workplace or workers will not give a full picture of occupational risks [4].

IoT technology offers a breakthrough in this area. Through Internet of things, physical objects can collect data and transmit it via connected networks [5]. In an occupational environment, wearables can provide worker-related information while environmental IoT sensors will enable continuous measurement of workplace conditions. Contemporary scientific literature speaks about the increasing role of IoT technology in occupational health and safety monitoring [6].

The application of wearables has made monitoring of worker-centered parameters possible [7]. Wearable devices can gather information on physiological parameters, body motion, posture, performed activities, fatigue-related parameters, environmental exposure. A recent scoping review of industrial and worker wearable sensors has categorized applications of wearable technology in gas monitoring, physiological monitoring, fatigue and activity monitoring, environmental and physiological combined monitoring, advanced sensing systems.

Moreover, artificial intelligence has added new capabilities to IoT-based monitoring systems [8]. Instead of just collecting the values of sensors, AI algorithms can recognize activities, identify abnormalities, assess risk and assist in developing preventive occupational health interventions. A systematic review of the applications of AI in occupational health and safety in 2026 has found the applications of artificial intelligence in risk prediction, personal protective equipment detection, ergonomic monitoring, hazard prevention among others, along with issues of data quality, ethics and standardization [9].

2. OCCUPATIONAL HEALTH MONITORING AND THE NEED FOR SMART SYSTEMS

The process of occupational health monitoring includes regular observation of workplace and worker health to detect occupational hazards, prevent occupational diseases and minimize the accidents [10]. This type of monitoring includes physiological monitoring, environmental monitoring, behavioral monitoring, ergonomic monitoring, and location monitoring.

Main requirements for an effective occupational monitoring system include [11]:

- Continuity or sufficient frequency of observations;
- Measurement of worker and environmental parameters;
- Fast detection of abnormalities;
- Transmitting safety information;
- Prediction of developing dangers;
- Secure handling and processing of health information; and
- Effective transmission of warnings to workers and supervisors.

Limitations of traditional systems provide strong grounds for development of smart monitoring because human-dependent observations may not be continuous; fixed sensors may not provide information about individual exposure; periodic medical observations are very valuable sources of health information but do not cover changes during work shifts. In contrast, IoT-based systems may unite personal monitoring and environmental monitoring. For instance, a worker who is exposed to high-temperature conditions may be experiencing high ambient temperature, high humidity, high physical load, and high heart rate. These parameters can be analyzed together rather than interpreted separately [12].

Integration of monitoring is one of the key features of smart occupational health systems.

There are many studies investigating the use of IoT-based occupational health and safety monitoring at different workplaces such as coal mining, occupational noise monitoring, healthcare monitoring, and employee health monitoring. These works show the possibilities of using IoT, wireless communication and sensor network technology for better health and safety monitoring. The contributions of selected papers are described in Table 1.

Table 1. Author-Wise Review of Literature

Author(s) & Year	Research Focus	Technology/Approach	Major Contribution
Porselvi & Ganesh (2021) [13]	Coal mine safety and health monitoring	IoT and LoRaWAN	Developed an IoT-based approach for monitoring safety and health conditions in coal mines.
Marques & Pitarma (2020) [14]	Occupational noise monitoring	IoT-based real-time monitoring	Proposed a real-time noise monitoring system to support acoustic comfort and occupational health.
Abdulmalek et al. (2022) [15]	IoT-based healthcare monitoring	IoT healthcare technologies	Reviewed IoT-based healthcare monitoring systems and their potential for continuous health monitoring.
Ramani et al. (2020) [16]	Employee health monitoring	IoT-based health monitoring	Demonstrated the potential of IoT technology for continuous employee health assessment.

The above discussed papers show that IoT has already found its application in various areas of occupational health and safety. Nevertheless, current researches primarily concentrate on certain areas of applications like mine safety, noise monitoring, healthcare monitoring, and employee health. It means that there is a requirement for further research of development of an integrative occupational health monitoring system which would integrate various parameters into one intelligent system.

3. IOT TECHNOLOGIES FOR OCCUPATIONAL HEALTH MONITORING

The emergence of the Internet of Things (IoT) represents one of the major technological solutions to enhancing occupational health and safety through the continuous acquisition, transfer, and analysis of information coming from the worker and his/her environment. Occupational health applications relying on IoT involve the use of wearable devices, physiological sensors, environmental sensors, wireless communications, edge devices, cloud platforms, and intelligent analytics to deliver real-time information on health and safety risks [17].

Unlike traditional methods of monitoring that rely on periodic inspection or manual reporting, IoT technologies allow for continuous and location-specific monitoring of the changing conditions in the workplace. Among the factors that may be monitored using IoT include heart rate, body temperature, physical activities, posture, fatigue, noise, humidity, temperature, gases, and particulate matter. The combination of this data allows for a more thorough assessment of risks in the workplace and helps to detect health problems at an early stage and take preventive measures [18].

3.1 Sensor Technologies

Sensors are the core components of the IoT occupational health system. These can be categorized into four types, namely physiological sensors, activity sensors, environmental sensors, and location sensors.

Physiological sensors can be used to record heart rate, body or skin temperature, oxygen saturation, breathing, and other biological data. Activity sensors include accelerometers and gyroscopes that can monitor movements and postures.

Table 2. Major IoT Technologies Used in Occupational Health Monitoring [19]

Technology	Monitoring Function	Occupational Application
Wearable sensors	Physiological monitoring	Heart rate, temperature, fatigue
Accelerometer	Movement detection	Activity and fall detection
Gyroscope	Posture monitoring	Ergonomic assessment
Gas sensors	Hazard detection	Toxic gas monitoring
Temperature sensor	Thermal monitoring	Heat-stress assessment
Humidity sensor	Environmental monitoring	Workplace condition assessment
Noise sensor	Sound-level monitoring	Noise exposure
GPS/location sensors	Worker tracking	Emergency and restricted-area monitoring

Environmental sensors can measure factors like temperature, humidity, noise levels, gases, particulate matter, and smoke among others in the workplace. Specific sensors can be embedded for radiation, vibration, chemical exposure, and respiratory risks in certain industrial applications [20].

According to recent surveys, sensors continue to be the most widely utilized elements in IoT occupational safety and health systems, being divided into activity and environmental sensors.

3.2 Wearable Devices

With wearable technologies, the process of monitoring is no longer restricted to just one place but is made mobile in relation to the individual worker's movements. Wearable technologies, such as smart watches, sensor-based clothing, smart helmets, smart badges, belts, shoes, glasses, and personal protective equipment with sensors, can all act as wearable monitoring devices.

Applications of wearable technology include [21]:

- physiological monitoring;
- fatigue detection;
- activity recognition;
- ergonomics monitoring;
- fall detection;
- heat stress monitoring;
- location monitoring;
- environmental monitoring; and
- emergency monitoring.

A systematic review of workplace wearable technologies has shown that wearables are being used for ergonomic, physiological, environmental, and critical event risks, despite lack of real-world accident reduction evidence [22].

3.3 Communication Technologies

Following the sensing process, there is the need to transfer information to an information-processing system. This could depend on different factors and could involve Bluetooth Low Energy, Wi-Fi, Zigbee, LoRaWAN, cellular, and any other low power communications technology.

Bluetooth Low Energy would be especially suited for communications between wearable sensors and nearby devices due to low energy demands. LoRaWAN would be useful for larger industrial and farming sites due to its long-range and low power demands capabilities. Cellular communications technologies can provide support for mobile workers operating in geographically dispersed locations. Choice of the communications technology would depend on range, latency, bandwidth, reliability, energy consumption, network coverage, and workplace interference.

4. PHYSIOLOGICAL AND ENVIRONMENTAL MONITORING

Physiological and environmental monitoring forms an essential element of IoT-based occupational health management because the health of a worker depends on the physiological reaction of the person along with the environmental aspects of the workplace [23]. Physiological monitoring involves the use of wearable devices to capture information such as heartbeat, body temperature, oxygenation levels, physical activities, motions, and postures to diagnose any symptoms of fatigue, overload of physical activity, heat stress, or other kinds of abnormalities.

Similarly, the environmental factors of the workplace such as temperature, humidity, noise, toxic gas, smoke, and dust particles can be captured with the help of environmental sensors [24]. Thus, with the integration of these two sets of information with the help of IoT platform, it becomes possible for the system to develop a more holistic connection between workplace exposure and the physiological reactions of workers, which can help in shifting from reactive to preventive occupational safety management.

4.1 Physiological Monitoring

Physiological monitoring is critical for employee-focused occupational health systems [25].

- **Heart Rate:** Information about the amount of physical exertion and physiological effort could be gathered from heart rate monitoring. Heart rate monitoring combined with data on activity and environment could reveal abnormal cardiovascular responses.
- **Bodily Temperature:** Monitoring of body or skin temperature could aid in assessing heat exposure and physiological stress. Temperature monitoring is especially important for construction, mining, agricultural, and industrial occupations.
- **Oxygen Saturation:** Oxygen saturation sensors could prove useful for jobs with risk factors related to the respiratory system [26]. Nevertheless, readings from these devices might be influenced by various factors, such as motion and positioning of the sensor.
- **Movement/Activity:** Accelerometer and gyroscope-based sensors could be used to detect physical activity, lack of it, falls, repetitive actions, and postures. These readings could assist with fatigue and ergonomic assessments.

4.2 Environmental Monitoring

The environment can have a major impact on the health of workers.

- **Thermal factors such as temperature and humidity:** Necessary for determining thermal stress [27].
- **Noise:** Continuous monitoring allows detection of instances when the noise level exceeds the safe threshold.
- **Concentration of gases:** Can be detected using gas sensors for detecting the presence of carbon monoxide, carbon dioxide, and volatile organic compounds among others.
- **Particulates:** Significant for construction, mining, manufacturing, and other industries that produce particulate matter in the air.

Recent developments in the field have also included the use of respiratory monitoring through wearables such as sensors attached to respirators and masks [28].

5. SMART IOT-BASED OCCUPATIONAL HEALTH MONITORING ARCHITECTURE

Smart occupational health monitoring systems can be structured as multi-level architectures.

- **Level 1: Sensing Level -** Wearable and environmental sensors are used in the sensing level. Wearables are used for collecting physiological and activity information, whereas environmental sensors are used for collecting information on hazards in the workplace.
- **Level 2: Communication Level -** Information from sensors is sent via wireless communication technologies to gateway or processing nodes.
- **Level 3: Edge/Gateway Level -** Gateway analyzes sensor data, performs data aggregating, filtering, preliminary processing, and event detection. Edge computing is especially beneficial for emergency cases because decisions are not based on cloud communication.

- **Level 4: Cloud/Data Level -** Historical information is stored in the cloud platform, and large-scale data handling and analysis are conducted.
- **Level 5: AI Analytics Level -** Machine learning and deep learning algorithms analyze information from sensors and detect patterns related to occupational hazards.
- **Level 6: Application/Alert Level -** Information is presented via dashboards, mobile applications, wearable alarms, or control room applications [29].

Proposed Architecture

Worker + Workplace
↓
Wearable Sensors + Environmental Sensors
↓
IoT Communication Network
↓
Edge Gateway
↓
Data Cleaning and Feature Extraction
↓
AI/ML Risk Analysis
↓
Cloud Database and Dashboard
↓
Risk Classification and Prediction
↓
Real-Time Alert and Decision Support

This architecture combines the strengths of real-time sensing, distributed computing, and intelligent analytics [30].

6. CONCLUSION

IoT-based smart health-monitoring systems for occupational settings appear to be an exciting solution that will help improve workers' safety due to their constant, connected, and intelligent nature. The use of wearable physiological sensors and environmental sensors allows for simultaneous monitoring of both worker health conditions and potential workplace dangers, while IoT communication enables immediate data transfer and monitoring. Edge computing can help detect critical incidents quickly, but cloud computing and AI technologies can allow for historical analysis, classification of risks, prediction, and decision-making. The presented multi-level architecture shows how the process of sensing, communication, edge computing, AI analysis, cloud computing, and real-time alerts can work as an integrated occupational health system. Still, the development of such a system will require further improvements in reliability, energy consumption, connectivity, security, privacy, interoperability, and user acceptability.

REFERENCES

1. Kim, J. H., Jo, B. W., Jo, J. H., & Kim, D. K. (2020). Development of an IoT-based construction worker physiological data monitoring platform at high temperatures. *Sensors*, *20*(19), 5682.
2. Mehata, K. M., Shankar, S. K., Karthikeyan, N., Nandhinee, K., & Hedwig, P. R. (2019, April). IoT based safety and health monitoring for construction workers. In *2019 1st International Conference on Innovations in Information and Communication Technology (ICIICT)* (pp. 1-7). IEEE.
3. Singh, N., Gunjan, V. K., Chaudhary, G., Kaluri, R., Victor, N., & Lakshmanna, K. (2022). IoT enabled HELMET to safeguard the health of mine workers. *Computer Communications*, *193*, 1-9.
4. Tsang, Y. P., Choy, K. L., Poon, T. C., Ho, G. T. S., Wu, C. H., Lam, H. Y., ... & Ho, H. Y. (2016, November). An IoT-based occupational safety management system in cold storage facilities. In *6th International Workshop of Advanced Manufacturing and Automation* (pp. 7-13). Atlantis Press.
5. Zifac, J. A. (2025). Assessing the effectiveness of IoT-based safety monitoring Systems in Mitigating Workplace Hazards: a systems engineering approach. *Open Journal of Safety Science and Technology*, *15*(4), 311-332.
6. Valsalan, P., Baomar, T. A. B., & Baabood, A. H. O. (2020). IoT based health monitoring system. *Journal of critical reviews*, *7*(4), 739-743.
7. Chung, W. W. S., Tariq, S., Mohandes, S. R., & Zayed, T. (2023). IoT-based application for construction site safety monitoring. *International Journal of Construction Management*, *23*(1), 58-74.
8. Kuhar, P., Sharma, K., Hooda, Y., & Verma, N. K. (2021, August). Internet of things (IoT) based smart helmet for construction. In *Journal of Physics: Conference Series* (Vol. 1950, No. 1, p. 012075). IOP Publishing.

9. Al-Dulaimi, J., Cosmas, J., & Abbod, M. (2019). Smart health and safety equipment monitoring system for distributed workplaces. *Computers*, *8*(4), 82.
10. Vippalapalli, V., & Ananthula, S. (2016, October). Internet of things (IoT) based smart health care system. In *2016 International Conference on signal processing, communication, power and embedded system (SCOPES)* (pp. 1229-1233). IEEE.
11. Taştan, M. (2018). IoT based wearable smart health monitoring system. *Celal Bayar University Journal of Science*, *14*(3), 343-350.
12. Akash, M. A. S., & Sah, B. P. (2025). Smart Occupational Safety Management Through IOT Sensor Networks, Machine Learning, and Real-Time Risk Assessment in Chemical Processing Plants. *ASRC Procedia: Global Perspectives in Science and Scholarship*, *1*(01), 1958-1998.
13. Porselvi, T., & Ganesh, S. (2021, May). IoT based coal mine safety and health monitoring system using LoRaWAN. In *2021 3rd International Conference on Signal Processing and Communication (ICPSC)* (pp. 49-53). IEEE.
14. Marques, G., & Pitarma, R. (2020). A real-time noise monitoring system based on internet of things for enhanced acoustic comfort and occupational health. *Ieee Access*, *8*, 139741-139755.
15. Abdulmalek, S., Nasir, A., Jabbar, W. A., Almuhaya, M. A., Bairagi, A. K., Khan, M. A. M., & Kee, S. H. (2022, October). IoT-based healthcare-monitoring system towards improving quality of life: A review. In *Healthcare* (Vol. 10, No. 10, p. 1993).
16. Ramani, J. G., Madhusudan, S., Nila, A. L., Pradeep, A., & Manibharathi, S. (2020, March). IOT based employee health monitoring system. In *2020 6th international conference on advanced computing and communication systems (ICACCS)* (pp. 298-301). IEEE.
17. Tamilselvi, V., Sribalaji, S., Vigneshwaran, P., Vinu, P., & GeethaRamani, J. (2020, March). IoT based health monitoring system. In *2020 6th International conference on advanced computing and communication systems (ICACCS)* (pp. 386-389). IEEE.
18. Tamilselvi, V., Sribalaji, S., Vigneshwaran, P., Vinu, P., & GeethaRamani, J. (2020, March). IoT based health monitoring system. In *2020 6th International conference on advanced computing and communication systems (ICACCS)* (pp. 386-389). IEEE.
19. Häikiö, J., Kallio, J., Mäkelä, S. M., & Keränen, J. (2020). IoT-based safety monitoring from the perspective of construction site workers. *International Journal of Occupational and Environmental Safety*, *4*(1), 1-14.
20. Bhardwaj, V., Joshi, R., & Gaur, A. M. (2022). IoT-based smart health monitoring system for COVID-19. *SN Computer Science*, *3*(2), 137.
21. Savaridass, M. P., Ikram, N., Deepika, R., & Aarnika, R. J. M. T. P. (2021). Development of smart health monitoring system using Internet of Things. *Materials Today: Proceedings*, *45*, 986-989.
22. Lal, P., Ananthakrishnan, V., Swathika, O. G., Gutha, N. K., & Hency, V. B. (2022). 14 IoT-Based Smart Health Monitoring System. *Smart Buildings Digitalization: Case Studies on Data Centers and Automation*, 149.
23. Eeshwaroju, S., Jakkula, P., & Ganesan, S. (2020, September). IoT based empowerment by smart health monitoring, smart education and smart jobs. In *2020 International Conference on Computing and Information Technology (ICCIT-1441)* (pp. 1-5). IEEE.
24. Dinesh, K., Vijayalakshmi, K., Nirosha, C., & Krishna, I. S. R. (2018). IoT based smart health care monitoring system. *International Journal of Institutional & Industrial Research*, *3*(1), 22-24.
25. Madahana, M. C., Ekoru, J. E., Sebothoma, B., & Khoza-Shangase, K. (2024). Development of an artificial intelligence based occupational noise induced hearing loss early warning system for mine workers. *Frontiers in Neuroscience*, *18*, 1321357.
26. Kavitha, B. C., & Vallikannu, R. (2019, March). IoT based intelligent industry monitoring system. In *2019 6th International Conference on Signal Processing and Integrated Networks (SPIN)* (pp. 63-65). IEEE.
27. Eldemerdash, T., Abdulla, R., Jayapal, V., Nataraj, C., & Abbas, M. K. (2020). IoT based smart helmet for mining industry application. *Int. J. Adv. Sci. Technol*, *29*(1), 373-387.
28. Alekya, R., Boddeti, N. D., Monica, K. S., Prabha, R., & Venkatesh, V. (2021). IoT based smart healthcare monitoring systems: A literature review. *Eur. J. Mol. Clin. Med*, *7*(2021), 2020.
29. Kim, H., Tae, S., Zheng, P., Kang, G., & Lee, H. (2021). Development of IoT-based particulate matter monitoring system for construction sites. *International journal of environmental research and public health*, *18*(21), 11510.
30. Malapane, T., Doorsamy, W., & Paul, B. S. (2020, October). An intelligent IoT-based health monitoring system. In *2020 international conference on intelligent data science technologies and applications (IDSTA)* (pp. 95-100). IEEE.