



Technology-Enabled Monitoring and Artificial Intelligence Approaches for Assessing Tobacco Smoke Exposure and Respiratory Health Outcomes: A Scoping Review

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Abstract

There is a growing global concern about the impact of tobacco smoke on our lungs. Therefore, it is important to identify, detect, and measure this impact to better understand it. However, it is also important to recognize that traditional methods such as questionnaires and observing smoking behaviour can have biases. With advances in technology, new methods for identifying smoking behaviour have emerged. A review paper, based on existing literature, investigates the role of technology—especially AI and ML—in understanding how tobacco smoke exposure affects the human respiratory system. This review follows the guidelines established by Joanna Briggs for review papers. The literature search was thorough, covering major databases like PubMed, Scopus, and Web of Science, using keywords such as "detection methods," "AI," "environmental sensors," and focusing on studies from 2020 to July 2025. Out of 36 articles identified, after removing duplicates and screening titles and abstracts, 9 articles remained that met the full-text review and inclusion criteria. These articles discuss detection techniques involving wearable sensors, ambient sensors, and predictive algorithms that enable continuous monitoring for accurate detection of tobacco exposure. Scientific evidence confirms the link between tobacco smoke exposure and respiratory diseases, including COPD, along with their symptoms and decreased lung function. Advances in AI and sensor technologies hold promise for the detection and identification of tobacco use and related diseases, including tobacco-related respiratory conditions.

Keywords: Artificial intelligence; Environmental monitoring; Respiratory health; Smoke exposure assessment

1. Introduction

As a result of technological advancements, it is becoming more common to use artificial intelligence (AI) and machine learning technologies for analyzing large and/or complicated datasets. In order to facilitate this work, AI systems can collect real-time information from various sources, such as sensors, cameras, and wearable devices; thus allowing for better understanding of exposure events; predicting smoking trends; and identifying patterns among various data points within the collected datasets (Chong et al., 2023). Overall, the ability of these AI-based systems to provide algorithms capable of analyzing very large amounts of data, identifying multiple complexities in patterns, making predictive

analyses based on data, and enabling precision participation-based interventions will all help transform how tobacco control measures are implemented (Olawade et al., 2025). AI applications within the tobacco control field include using machine learning to create predictive models for individuals at high risk for initiating or relapsing into use. Additionally, the development of smart cities would not occur without the proliferation and interconnectivity of devices and sensors based on advances in computer technology (Khan et al., 2025). Therefore, while these technologies continue to be developed, current smoking detection techniques are becoming more sophisticated and no longer rely on



standard/physical tools such as a combination of wireless or cellular networks and wearable or smoke detection devices (Ortis et al., 2020) Accelerometers and inertial sensors can be implemented in machine learning models to identify gestures that indicate whether someone is smoking. For example, the way people move their hands towards their mouths while smoking can be identified in real-time automatically with these machine learning models. With deep learning-based computer vision methods, computer models can also identify cigarettes and the act of smoking from video streams in real-time based on the visual characteristics of objects and their proximity in the different frames (Chong et al., 2023). In addition, many types of sensors found in wearable and remote devices capture a variety of physical characteristics that can relate to either the user or the environment around them and then relay this information to various other devices. Together, the data collected from multiple wearable or remote devices can be processed and integrated in order to improve the level of insight provided to the end user, as described by (Ortis et al. (2020.) Every year, tobacco products kill approximately 8 million people, making it one of the largest health risks facing the world today, as stated by the World Health Organization (WHO, 2024). The major contributor to the increased mortality rate associated with tobacco products is the harm that smoking causes to the lungs; this harm is usually not detected until lung function has already been affected (Wang et al., 2023). The indoor environment becomes a hazard as the smoke gets trapped in the indoor environment; tobacco smoke stays in the air for long periods (Protano et al., 2020). The indoor environment becomes a hazard as the presence of tobacco smoke increases the level of particulate matter in the air, thereby deteriorating the indoor air quality (Protano et al., 2020). One of the most well-known health effects of tobacco consumption is respiratory diseases. The inhalation of cigarette smoke causes the tissues lining the respiratory tract to become inflamed and damaged or to lose their ability to function properly (Jayes and 2021) (see page 103 for texture details). The epidemiological evidence indicates that the incidence of asthma attacks, bronchitis, and other forms of chronic obstructive

pulmonary disease (COPD) has increased in both children and adults due to exposure to tobacco smoke (Wang et al., 2023). There is also evidence of the adverse effects of tobacco smoke on the development of the child. The literature indicates that exposure to tobacco smoke during early childhood is known to result in the impairment of lung development and reduced lung function in later years (Jayes et al., 2021). The health impacts of tobacco smoke have been researched over the years, but when we add the component of modern technology—such as monitoring systems, AI tools, etc.—we see that the scope is quite wide and touches many different aspects. However, there isn't a clear synthesis that shows how these tools are being implemented to detect, measure, or even predict the risk of tobacco use. This review has set out to bring together the different AI tools for surveillance and detection, tools to measure the risk, tools to provide interventions for individuals, and tools to measure the efficacy of those interventions. The key to linking theory and research is to find ways to bridge the gap between methodology and what the research shows. Therefore, the purpose of this scoping review is to identify the existing research in the area of smoke exposure detection technology and AI, in relation to respiratory health.

2. Method

A scoping review was chosen to characterize the current status of available evidence on tobacco smoke exposure outcomes relating to respiratory health. This scoping review adhered to the PRISMA Extension for Scoping Reviews (PRISMA- ScR) and to the Joanna Briggs Institute (JBI) scoping review standards[1]. This scoping review used the methodological framework developed by Arksey and O'Malley, as well as the most recent JBI recommendations for scoping reviews. The scoping review process consists of a series of steps, which include, first, formulating a research question, followed by a search for studies related to the formulated research question, then a selection of studies related to the research question, followed by data collection from the selected studies, and finally, integrating all the data collected from all the selected studies[2].

Table 1: Proposed data extraction for scoping review

s.no	Author/ year/country	Participant characteristics	Study design	Data collection/method	Result	
					Limitation	Conclusion
1.	Ayadi H et al 2024,France	Adults with varying smoking status	Observational study	Audio recordings +AI analysis	Environmental noise affects accuracy	Vocal biomarkers are promising non-invasive tools for smoking detection
2.	Chong et al.,2023	Individuals in vedio dataset	Experimental study	Deep learning	Limited real-world testing	CNN models can be used for surveillance and smoke prevention
3.	Caccamisi A et al., Sweden	Clinical patient record	retrospective	Electronic health records	Data quality variability	NLP models are effective for automated smoking status classification
4.	Wang X et al.,2023, china	Smokers	Cross-sectional study	Large population data sets	Limited generalisability	AI can identify high-risk individuals and support early intervention
5.	Ortis et al.,2020, Italy	Smokers and individuals attempting to quit smoking	Narrative review	Literature review previously published	Lower use adherence to digital smoking cessation tools	Wearable sensors and mobile applications for real-time
6.	Khan A et al.,2023,China	Individuals captured in surveillance	Experimental study	Deep learning with computer vision	Performance may vary with lighting, occlusion, and crowded conditions	In smart cities, a CNN-based system can help lower the smoking exposure
7.	Ayadi et al.,France	Adult participant with a different smoking status	Observational study	Participants from colvive voice study	Background noise and variability in recording conditions may affect the accuracy	Potential uses in public health and smoke exposure
8.	Nryinarish et al.,2022, Indonesia	Health professionals	Cross-sectional study	ANN machine learning tool	Limited generalisability	ANN models are a helpful instrument in risk perceptions and smoking behaviour
9.	Lakatos et al., 2023,Hungary	Individuals with multimodal data	Experimental study	Multimodal data	Reduced generalizability	Multimodal deep learning is a promising approach for smoking

Table 2: Proposed search strategy in PubMed, Web of Science, and Scopus

S.no	Databases	Search terms	RESULTS
1.	PubMed	("tobacco smoke" OR "environmental tobacco smoke" OR "smoking exposure") AND ("artificial intelligence" OR "machine learning" OR "deep learning" OR "neural network*" OR "computer vision" OR "pattern recognition") AND ("detection" OR "monitoring" OR "assessment" OR "identification" OR "prediction")	16
2.	Web of Science	((("environmental tobacco smoke" AND ("artificial intelligence" OR "machine learning" OR "deep learning")) AND ("respiratory health" OR "lung function" OR "respiratory disease"))	11
3.	Scopus	TITLE-ABS-KEY ("tobacco smoke" OR "second hand smoke") AND TITLE-ABS-KEY ("artificial intelligence" OR "machine learning") AND TITLE-ABS-KEY (detection OR monitoring OR "exposure assessment")	9

Figure 1. PRISMA -ScR flowchart

3. Results And Discussion

3.1. Results

Studies that were found via database source selection are represented in Figure 1 (PRISMA Sc-R Flow Diagram). The systematic review process used three electronic databases (PubMed, Scopus, and Web of Science), with a final result of thirty-six articles that met eligibility criteria. After the removal of ten duplicated records, twenty-six articles were included in this systematic review[3]. After reviewing the available titles and abstracts of the remaining articles against the established eligibility criteria, a total of four articles were excluded, having not fulfilled the eligibility criteria. The remaining articles underwent a methodological check—the majority were excluded from consideration because they either had no mention or discussion of secondhand tobacco smoke exposure, or provided no information regarding the use of technology (i.e., Artificial Intelligence) or technology-based methods. Ultimately, there were a total of nine articles that were deemed eligible and included in this systematic review that met the pre-established criteria[4]

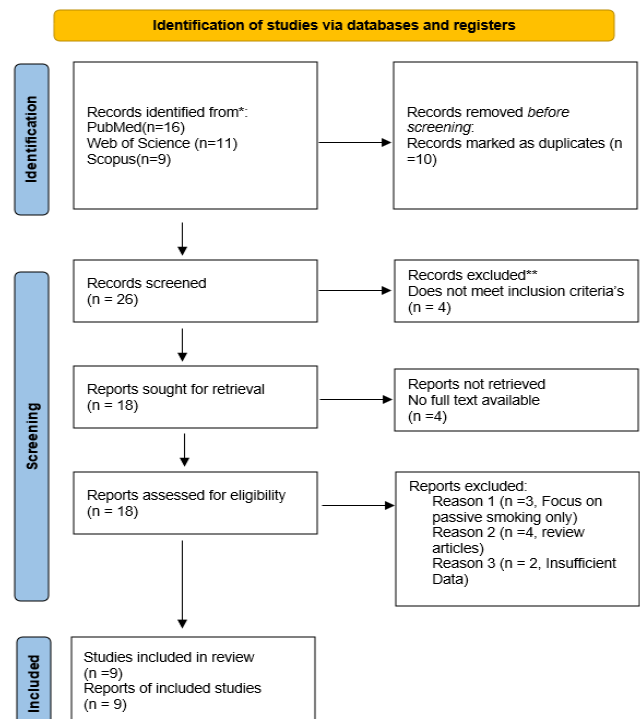


Figure 2 Identification of studies

3.2.Theme 1:AI Technology for Smoking Detection

The use of AI systems (automated) to identify/quantify people's tobacco usage/exposure to tobacco[5] (e.g., smoking, second-hand smoking) through a range of different input methods (e.g., vision/video, motion/accelerometer, audio/sound) provides an opportunity to identify if smoking behavior occurs. This is an advancement beyond confirming smoking behavior through self-reports from smokers. This has been found to increase the accuracy of smokers' self-reports of smoking behavior by reducing self-reporting biases and allowing ongoing monitoring of smoking behaviors over time (and in a range of locations) (Ortis et al., 2020; Chong et al., 2023).

3.3.Deep Learning and Computer Vision for Smoking Behavior Detection

Extensive research has been carried out to detect smoking actions in digital images/videos using deep learning algorithms, especially convolutional neural networks (CNNs). This is done by examining the spatial/temporal relationships between images to detect significant visual characteristics of smoking, such as cigarettes, smoke, and hand-to-mouth actions[6]. CNNs are utilized in various investigation and regulation-oriented scenarios (e.g., smart city surveillance systems) to enable non-intrusive and real-time monitoring of smoking actions. Although research shows that CNN-based models for smoking detection achieve very high detection accuracy, certain environmental factors may influence it (Chong et al., 2023). Nevertheless, computer vision is an excellent approach for the automation of large-scale detection of smoking actions[7].

3.4.Sensor-Based Detection Using Wearable Technologies

Wearable sensors are being utilized in an innovative manner to obtain information about the smoking habits of people. These sensors can track the motions that the hands make when the person takes a cigarette, for instance. This provides a constant flow of information about the smoking habits of the person and the quantification of the frequency and duration of the smoking habit of the person. The utilization of wearable sensors for the measurement of the smoking

habits of a person is a more precise approach compared to the traditional approach of visual observation of the smoking habits of the person. However, it also poses some challenges with regard to compliance with the utilization of the wearable sensor for the measurement of the smoking habits of the person and the ability to differentiate between the motions that appear similar but may not be the same (chewing gum and smoking) (Ortis et al., 2020). The potential for the utilization of this technology for the provision of individualized support for the monitoring of the smoking habits of the person and the provision of interventions for behavior change is promising[8]

3.5.Audio-Based Detection Using Digital Vocal Biomarkers

New research has looked at how Digital Vocal Biomarkers Can Identify Your Smoking Status Using Non-Invasive Technologies. AI Models Analyze the Acoustic Geo Features of Voice (frequency, quality and stability of sound) As Influenced by Your Smoking Pattern on Your Respiratory/Vocal Health. The Non-Invasive Nature of This Method Helps With Remote/Scalable Monitoring, Which Has Many Uses Within[9] Telehealth and Screening For Large Groups Of People. The Models Are Subject to Environmental Quality (recording quality, environmental noise, and Variability/Minimum Population) Differences That Will Affect Their Accuracy and Therefore Must Be Validated Further (Ayadi Et Al., 2023)

3.6.Theme 2: Technological and Artificial Intelligence Applications in Exposure Mapping

New technologies like AI have greatly increased the ability to monitor the timing and locations of people's exposure to tobacco smoke and how it changes over time[10]. As shown in the results section, the ability of AI technology to monitor the smoking behavior of people objectively and in real-time is beyond the ability of traditional[11] self-reports (Ortis et al., 2020; Chong et al., 2023)

3.7.Machine Learning and Predictive Modeling Approaches

Several machine learning methods have been employed to classify the characteristics of smoking



behavior and measure the level of health risks associated with smoking. These methods access data from various sources, such as sensors and wearables, to[12] identify characteristics and measure the level of exposure to smoking. Moreover, these methods can also forecast the probabilities associated with respiratory disease risks, such as COPD, for smokers (Wang et al., 2023). In addition, deep learning methods, such as CNN, can be employed to detect smoking behavior in visual[13] media (Chong et al., 2023)..

4. Artificial Intelligence–Based Data Analysis

Machine learning researchers have always sought to identify smoking patterns and predict the health hazards associated with smoking habits. Using sensor data and health records, we can plot the smoking patterns for an individual and determine the amount of cigarette smoke that has been inhaled by that person based on the available data. We can even predict[15] the chances of getting respiratory diseases like COPD, as demonstrated in Wang et al. (2023). Apart from the conventional methods, deep learning methods like CNN have been very successful in identifying smoking patterns using images and videos, as demonstrated in Chong et al. (2023).

4.1. Digital Surveillance and Monitoring Tools

For example, digital monitoring technologies such as smart sensors and environmental meters may record a person's moment-to-moment exposure to tobacco smoke by continuously monitoring their environment. This technology may offer an accurate and objective measure of an individual's[16] exposure to tobacco smoke and other environmental pollutants. This technology, when connected to mobile technology and IoT, may aid in creating a picture of an individual's exposure, which may inform timely public health interventions (Ortis et al., 2020). Recent studies have increasingly shown that the role of AI and technology-based systems is increasing in the detection, monitoring, and analysis of smoke-related behavior and tobacco exposure. The evidence suggests that the detection of tobacco smoking behavior by AI-based detection systems, such as deep learning, wearable sensors, and sound-based models, not only detects tobacco smoking behavior with high accuracy but also monitors the

behavior in real-time by combining multiple data sources such as video, motion, and audio (Ortis et al., 2020; Chong et al., 2023; Ayadi et al., 2024). The AI-based approaches to detecting also overcome the limitations of the conventional approaches to self-reporting through the use of continuous and objective approaches to monitoring. In addition, the AI approaches to detecting the risks of smoking also reveal the significance of machine learning and predictive analytic practices to piloting the classification[17] of the smoking status, evaluation of health risks, and developing early identification approaches to individuals at risks of using or continuing to smoke. NLP was used to extract the related information, and predictive approaches were used to provide identification of individuals at risks of using or continuing to smoke. Using various data sources, such as sensor data, clinical data, audio data, and video data, may help to expand our knowledge regarding the ways in which humans smoke and are exposed to tobacco. Digital monitoring systems may help to track the ways in which humans smoke and are exposed to tobacco in real time in their daily lives, enhance the precision with which exposure can be measured, and create avenues for conducting large-scale public health surveillance. The involvement of artificial intelligence in public health activities may help to improve surveillance by predicting disease risks and proposing strategies for intervention. These strategies may be employed for smoking cessation, assessing the health status of the general population, and creating new avenues for exploring the relationship between exposure to tobacco and respiratory health. Overall, the results show promising potential for the application and effectiveness of AI and technology-based methods for enhancing the detection and evaluation of tobacco smoke. However, to make these potential applications a reality, more research needs to be conducted to address concerns regarding the effectiveness of these methods in generalizing, incorporating multimodal systems, and their practical applications[18].

5. Discussion

To better understand the impact that tobacco smoke is having on respiratory health, a scoping review has



been conducted with respect to how advanced technology & artificial intelligence (AI) can be utilized to detect & identify exposure to tobacco smoke in various environments. The negative impact of tobacco smoke exposure on respiratory health has been outlined clearly in the literature (Jayes et al., 2021) in relation to chronic obstructive pulmonary disease (COPD) developing, increasing the risk of respiratory[19] infections occurring & causing a reduction in lung function, among many others. Each of the AI applications used in this current research contributed positively in assessing behaviours associated with tobacco use and identifying instances of exposure to tobacco smoke. As more and more researchers have noted an increase in access to and ability to utilize advanced technology to monitor for indoor tobacco smoke exposure, several recent studies have identified a significant increase in use of technology to monitor for indoor tobacco smoke exposure using environmental monitoring systems (EMS), including wearables that can measure PM (particulate matter) producing more accurate, objective and unbiased data than previously reported literature (Protano et al., 2020). Similarly, machine learning and AI have also been employed to analyse datasets of environmental health with associated risks on respiratory health by detecting patterns associated with tobacco smoke exposure. As been discussed earlier, another advantage is that sensor-based or wearable technology has the potential to monitor smoking behavior with high accuracy; that is, 90% accuracy is achievable using accelerometers or gestures (Ortis et al., 2020). Computer vision has also been identified as a method that has the potential to measure and classify various forms of smoking behaviours using deep learning (Chong et al., 2023). This has the potential to completely avoid the use of self-reported data. One of the notable developments in this field is the application of machine learning to analyse clinical data. Studies that have applied natural language processing (NLP) for data extraction with respect to data about smoking status using electronic medical records (EMRs) have been very successful, and this is because this technique has proved to yield high accuracy in this respect. This is helpful in conducting a wider scale of population

surveillance. Moreover, predictive analytics with the help of AI, aiming to predict the risk of diseases such as COPD, is also applied. In spite of the developments made in technology, there are still several methodological challenges to be addressed. Reliability and validity of the models are adversely affected when the data sets used are small and/or biased, as is the case in the majority of studies (Ortis et al., 2020). In addition, user behaviour and environmental conditions can also influence the accuracy of the sensor data. Another challenge is that the environment in which AI model validation takes place is not representative of actual smoking patterns (Chong et al., 2023). Significant differences are seen in the study designs, demographic characteristics, and methods of assessing exposure. This highlights the need for a standard approach to be followed in all studies. Going forward, studies should be conducted utilizing the latest exposure monitoring technologies and AI models to reveal the link between tobacco smoke exposure and lung health. Our analysis shows that AI technology is increasingly being used in the monitoring and analysis of the environment, particularly in evaluating exposure to tobacco smoke. There is a possibility of a more objective evaluation using AI and sensor technology. Assessments of exposure to tobacco smoke are expected to be more accurate as AI usage increases[20].

Conclusion

New technology is been analysed to identify smoking behaviours through AI. What makes them different from existing ones is their objectivity, originality, and real-time assessment. There are many techniques out there, but there is no standard way to apply them, and they are not yet extensively tested in real-world scenarios. The challenge is the variety of challenges that come with applying the techniques, which might complicate the detection of tobacco aerosol. These challenges need to be addressed to develop a reliable platform to identify smoking behaviours early. Future research needs to be conducted on the scope that has been widened to include various kinds of multimodal data and to develop a unified approach. The impact that AI may have on future tobacco control and respiratory health research is significant. However, to leverage the potential of AI to the fullest and make



the most out of the advantages that AI-based methods for detecting smoking provide, we need to move forward with sound methodologies for these techniques.

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