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Air pollution as an element of under- and postgraduate medical education: A narrative review of the curricula of Polish medical schools and specialty training programs

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Abstract

The aim of this narrative review is to investigate whether the current curricula of under- and postgraduate programs training physicians in Poland cover air pollution and to what extent. For this purpose, the newest versions of the official curricula of selected postgraduate specialty programs and medical universities' curriculum criteria were analyzed. The investigation indicates that the topic of air pollution is in many cases included as an element of physicians' education, but to a very limited extent and without adequate information that is essential for effectively communicating its health risks to future patients.

Keywords: medical education, air pollution, postgraduate, university, specialty, residency

Introduction

Air pollution is a growing concern in many parts of the world, including Europe (Khomenko et al., 2023; Reis et al., 2022). It has been proven to increase the incidence and mortality of various non-communicable and communicable diseases, including cancers, upper respiratory tract diseases and infections, and cardiovascular, autoimmune, and

neurological diseases (Sun et al., 2016; Weuve et al., 2021; Renzi et al., 2022; Karimi & Samadi, 2024). It therefore poses a major health threat, generating various types of additional healthcare-related costs (Manisalidis et al., 2020).

European Context

In the European Union, it has been estimated that as many as 300,000 additional deaths are attributed to air pollution each year (Council of the European Union, n.d.). It is important to note that the European Union's legislation for reducing air pollution plays a pivotal role in introducing and accelerating Poland's measures at the national level. This is, for the most part, because of the strict limits on each pollutant that countries are expected to meet before the year 2030 (European Parliament and Council of the European Union, 2024). In a broader perspective, this is a part of the EU's goal of "zero pollution by 2050," which was established on the assumption that the health and economic burden of air pollution in Europe is excessive. At the same time, new documents underscore the notion of clean air and the right to information about air quality as fundamental citizen rights.

The key new document mentioned above is the revised version of the Ambient Air Quality Directive (European Parliament and Council of the European Union, 2024), adopted in 2024. One of its goals is to reduce premature deaths due to air pollution by 55% and achieve €121 billion in savings in healthcare, education, and socioeconomic costs (European Environment Agency, 2024a). One of the most important elements of the new directive is the revision of annual and daily maximum concentration limits for each pollutant and setting threshold concentrations in 1 day or 1 hour which require reporting and alerting the public.

For fine inhalable particles with a diameter of 2.5 micrometers and smaller (PM2.5), the mean annual limit has been reduced from 25 $\mu g/m^3$ to 10 $\mu g/m^3$. The new daily maximum concentration is 25 $\mu g/m^3$ and 50 $\mu g/m^3$ is the alert threshold.

It is important to mention that even after these changes, the EU's proposed limits are still higher than those currently recommended by the World Health Organization (2021). However, the limits are ambitious, considering the fact that most parts of Poland notoriously exceed these thresholds (European Environment Agency, 2024b). The legislation is meant to be implemented into national law by the end of 2026.

Polish context

Among all the European Union member states, Poland has been known to face dangerously high levels of air pollution, especially in the cities. The most recent report on air pollution in European cities, published by the European Environment Agency in 2024 and based on data collected between 2022 and 2023, highlighted the fact that 6 of Europe's 20 most polluted cities are located in Poland (based on mean annual PM2.5 concentration) (European Environment Agency, 2024c). These results do show some minor improvement in the overall state of Poland's air quality when compared to a previous report presented in 2021, which indicated that 5 out of Europe's 10 most polluted cities were in Poland (Tilles, 2021). The city of Nowy Sącz, located in the south of Poland, had the worst air quality in Europe, with a mean annual PM2.5 concentration of 27.3 $\mu g/m^3$. In the recent report, this value dropped to 24 $\mu g/m^3$ and the city ranked second (European Environment Agency, 2024c). It is critical to note, however, that even with an improvement of mean annual levels, the frequent temporary exceedance of limits still poses a great health risk.

The sources of air pollution in Poland

Currently, the main pollutants exceeding the EU's limits in Poland include PM2.5, PM10, benzoapirene and N02 (World Bank, 2019). The highest concentrations are typically observed during the heating season in the late afternoons (starting from 6 pm).

PM2.5 particles, because of their small size, are considered to be the most harmful pollutants and are currently the biggest concern in Poland. PM2.5 emissions tend to peak in the winter months in large urban agglomerations and in the southern regions of Poland. The main source of PM2.5 is undeniably the combustion of solid fuels (and sometimes even domestic waste) in stoves and boilers in residential buildings for the purpose of heating. Traffic and industrial activity are also considered to be significant sources of this pollutant.

Benzo(a)pirene pollution is notably higher in comparison with other EU states, with some Polish agglomerations reaching five times the EU's threshold limit value of 1 ng/m^3. Again, exceedances are observed during the winter months, especially around larger cities. It comes mainly from burning wood and different solid fuels in residential areas, as well as motor vehicles and heavy industry (World Bank, 2019).

Health burden of air pollution in Poland

Multiple studies conducted in Poland have provided evidence of poor air quality having a significant impact on health (Nazar & Niedoszytko, 2022), resulting in additional hospitalizations, an increased number of cardiovascular episodes, and premature deaths – all of which could be avoided.

A recent study (Dąbrowiecki et al., 2025) examining the risk of hospitalization due to acute or chronic coronary syndrome in connection to air pollution proved that exposure to PM2.5, P10, and N02 was associated with a higher risk of admission due to ischemic heart disease. This was a large study, analyzing data from the three largest agglomerations in Poland over 5 years.

Higher morbidity due to cardiac episodes and air pollution in Poland was confirmed by Kuźma et al. (2024) in a report that analyzed the risk of STEMI and N-STEMI episodes in relation to PM2.5, NO2, and S02 levels. It was found that higher concentrations of these pollutants increased the risk of admission due to STEMI and N-STEMI.

A study by Holnicki et al. (2017) investigating the health burden of air pollution in the capital city of Poland, Warsaw, estimated that each year 2,800 deaths can be attributed to poor air quality (out of which 82% can be attributable to elevated PM2.5 levels and 16% to exceeding N0x normative thresholds). The study also showed that the effects of air pollution on cardiovascular risk in Poland are most significant for young people, women, and residents of rural areas, especially socioeconomically challenged ones.

Physicians' professional training in Poland

The process of training physicians in Poland involves two educational levels, undergraduate and postgraduate professional education. The first stage requires graduating from a medical university after a 6-year program to obtain the title of doctor of medicine (MD). In order to be able to receive a full medical license, each graduate is obliged to complete a 13-month internship in a clinical setting and to pass the state medical exam.

However, ending one's professional training at this stage is often insufficient to practice clinically in a medical specialization. The vast majority of medical doctors continue into specialization training programs (residency), allowing them to obtain the title of a specialist in a given field of medicine. The length of residency programs varies greatly, from 4 to 8 years, and some of the programs encompass two parts: foundational training in a broader area of medicine (e.g. internal or pediatric medicine) and specialist training (e.g. pulmonology or cardiology). Some programs (e.g. hypertensiology) are only intended for physicians who have already completed residency in a different specialization.

Methodology

In this narrative review, the official national law describing the teaching standards of medicine required in all Polish universities (Ministry of Education and Science, 2023) and 12 specialization training programs was reviewed to find any mentions of the topic of air pollution. As for the specialization programs, the 12 fields that were most appropriate for this type of content were selected and searched: public health, epidemiology, allergology (with internal medicine as a basic module), pulmonology, pediatric pulmonology (with pediatrics as a base module), hypertensiology, cardiology, pediatric cardiology, otolaryngology, pediatric otolaryngology, rheumatology, and clinical toxicology. Each curriculum came from the official public source, the Center for Postgraduate Medical Education (n.d.). This institution is in charge of creating the programs. As the curricula tend to change quite frequently, only the newest versions were considered (published in 2023, in some cases updated in 2024).

Results

University curriculum

In Poland, all universities approved to teach medicine are obliged to follow the rules disclosed in an ordinance of the Ministry of Science and Higher Education (2023). This act encompasses all of the elements of the curricula, the exact scope of knowledge, and the specific skills required to become a doctor of medicine. This document does not specifically mention the term "air pollution." However, upon analysis, there is some content which may (but not necessarily) indirectly refer to this issue:

> The graduate has knowledge and understanding of: […] consequences of human exposure to chemical and physical agents and principles of prevention, […] pathogenesis of diseases, including genetic and environmental predisposing factors, […] epidemiological and environmental predisposing factors, causes, symptoms, principles of diagnosis and treatment in the most common diseases in children and their complications, including […] respiratory system diseases and allergies. […] Epidemiological and environmental predisposing factors, causes, symptoms, principles of diagnosis and treatment in the most common diseases in adults and their complications, including […] cardiovascular diseases, respiratory diseases, […] allergies [as well as …] principles of health-promoting behavior.

Whereas these paragraphs could be interpreted as referring at least partially to the health consequences of exposure to air pollution, in reality it is uncertain and leaves room for individual evaluation.

Curricula of the specialization programs

The specialization training programs analyzed for this review differed significantly in terms of the amount of information about the health consequences of air pollution and methods of preventing it. Below, they are all discussed in turn.

1. Public health

In the 4-year specialization training for the field of public health, the topic of air pollution is raised directly twice, as is – more importantly – the issue of indoor air quality, which is often omitted from the discourse: "the importance of environmental and behavioral factors for the health of the population and the development of diseases: factors of the physical and anthropogenic environment, atmospheric and indoor air."

Another mention in the curriculum comes from the course called Health Determinants: "environmental physical and anthropogenic determinants of health (atmospheric and indoor air, food, soil, water." It should also be assumed that the several mentions of environmental conditions or factors at least partially also refer to the issue of diseases caused and mediated by air pollution and counteracting its effects: "diseases caused by environmental conditions," "relationships between these diseases [non-communicable diseases, mainly cancers and circulatory system diseases] and risk factors, including environmental factors," or "assessment of the importance of individual environmental factors […] in shaping the health status, including the ability to identify and eliminate factors harmful to health."

During specialization training, learning about the institutions involved in monitoring air quality and studying its health and economic effects, such as the World Bank and the European Environment Agency (EEA), is also required. An integral part of training for the public health specialization is the specialist courses, i.e. blocks of classes devoted to specific, broad issues important for the field.

In addition to the aforementioned course, Health Determinants, a course called Prevention and Health Promotion is also required. Importantly, it is also part of the training for other specializations, including epidemiology and all fields with a specialist module in internal medicine. One of the topics covered is "applications of health prevention and promotion (including recommendations, actions, methods, tools, materials, etc.) for practical disease/health problem control, [including] current health recommendations in the context of disease risk factors or specific diseases/health problems (e.g. air pollution [or] climate change)."

2. Epidemiology

In the curriculum for epidemiology residency, apart from the aforementioned course, Prevention and Health Promotion, there are no direct references to the quality or pollution of atmospheric or indoor air. However, the requirements repeatedly address the topic of environmental pollution (municipal and occupational) and quite broad "environmental factors," e.g. "the importance of individual environmental and social factors in shaping the health status, including the ability to identify and eliminate factors harmful to health" or "health effects of exposure to harmful environmental factors, including sources and routes of exposure to harmful environmental factors." The program also refers several times to institutions and programs that are key to improving air quality as sources of knowledge about pollution: "sources of information on environmental epidemiology: a) World Health Organization programs, b) European Environment Agency programs."

Likewise, in the course on "Epidemiology of non-communicable diseases with elements of environmental epidemiology," the issue of "epidemiology of conditions and diseases related to communal and occupational environmental pollution" is discussed. However, it should be noted that this is one of several topics discussed during a 5-day course of a residency program which lasts a total of 3 years.

3. Allergology

During the basic module on internal medicine in the specialization training in allergology, "air pollution" appears directly only once, in the aforementioned course, Prevention and Health Promotion.

In the specialization module, during the course on "Prevention and treatment of allergic diseases," the list of required skills in the field of preventive measures includes "environmental interventions – methods of reducing exposure to allergens, reducing exposure to pollutants," which, it can be assumed, concern mainly air pollution in this context.

4. Pulmonology

As previously mentioned, the basic module of the training includes the course Prevention and Health Promotion. In the specialization module, there are no direct references to air pollution. The program only references "industrial dust and pneumoconiosis" (as part of the course on occupational respiratory diseases) and "prevention of obstructive lung diseases" in the course on obstructive diseases.

5. Pediatric pulmonology

The specialization program in pediatric lung diseases includes a basic module in pediatrics and a specialization module in pediatric lung diseases. This is one of the programs in which many direct references to air pollution can be found. The basic module curriculum mentions, although indirectly, "causes of upper and lower respiratory tract infections," "the influence of genetic and environmental factors on allergic diseases," and "primary and secondary prevention of allergies." The basic module also includes the course Prevention and Health Promotion, which has been mentioned before.

The most interesting part is certainly the scope of the specialization module program, in which direct mentions can be found about pollution: "the influence of air pollution on the condition of the respiratory system: the influence of particulate matter and volatile gases on the respiratory tract, diseases related to exposure to pollution." The ability to "recognize the influence of tobacco smoke and other air pollutants on children's health" is also required. The test also describes "environmental factors relevant to asthma and other respiratory disorders, [including] the impact of passive smoking and air pollution on the incidence of asthma."

This last issue is mentioned again in the same wording as a criterium for passing the asthma internship.

6. Pediatric cardiology

The specialization program in pediatric cardiology includes a basic module in pediatrics and a specialization module in pediatric cardiology. The content of the basic pediatrics module is the same as described above. The specialization module does not have any information on air pollution in its program.

7. Clinical toxicology

The clinical toxicology specialization program is based on the basic module in internal medicine, the content of which was discussed above. The specialization module, during the course on "the basics of industrial and environmental toxicology with consideration of neoplastic diseases" discusses "methods of diagnosing and preventing the most common health hazards related to exposure to toxic factors in the environment and workplace." However, this does not necessarily mean air pollution, but may rather concern topics closer to health and safety at work and occupational medicine, especially considering the wording of the following passages: "criteria, method of determining and interpreting the highest permissible concentrations in the air at workplaces" and "neoplastic diseases related to exposure to chemical compounds and specific technological processes."

8. Other specializations

The subject of air pollution was only directly addressed by the programs of the remaining five specializations during the 5-day course called Prevention and Health Promotion (as described above). The specialization module does not contain any direct or indirect references to the quality of outdoor or indoor air. This situation concerned the specializations in cardiology, hypertensiology, otolaryngology, pediatric otolaryngology, and rheumatology.

Discussion

The above analysis indicates that the topic of air pollution seems to be discussed rarely – if at all – in both university and postgraduate curricula. Certainly, this can be explained by the fact that the primary goal of teaching at this stage is to provide information and skills that are intended specifically to treat diseases. Due to the amount of information that needs to be covered, prevention – including the prevention of diseases caused by air pollution – remains a lower priority.

From a practical perspective, in a healthcare system that is characterized by a shortage of specialists – especially those working in the public system – long waiting times for specialist treatment, and the consequential short consultation times per patient, informing patients about the current level of air pollution or personal protection methods may not, again, seem to be the ideal way to use this time.

Furthermore, one may wonder to what extent the obligation in this area should rest with doctors and to what extent it could be taken over by other public institutions, which is already happening to some extent. Some municipalities ("Program czyste powietrze – oddech dla Opola," 2022) inform their residents when air pollution exceeds a certain level or make this information publicly available in smartphone applications, on websites, or near measuring devices in the vicinity of public utility buildings. Some alerts, along with information about recommended personal protection, are sent via text messages by the Government Security Center (Więckowska, 2021).

The topic of air pollution is present in Polish medical discourse, although it is the subject of very few studies to date. At the time of writing this review, the author has managed to find only two surveys checking Polish doctors' subjective knowledge on the topic of air pollution. Each of the studies assessed the doctors' knowledge of the subject as low (Zielonka, 2021, 2022). Pulmonologists declared sufficient knowledge of the issue in only 16% of cases; their knowledge was weaker than that of patients suffering from lung diseases and they declared checking the current level of pollution less often than patients (Zielonka, 2021). The second study, conducted among doctors of different specializations working in the same hospital, showed that only 5% of doctors knew the limit

concentrations of air pollutants and only 3% raised this topic with patients (Zielonka, 2022). These findings indicate that it still remains a niche topic among doctors.

Increasing physicians' awareness of air pollution could potentially bring tangible benefits in improving the health of the Polish population. Although air pollution itself does not require pharmacological treatment in patients, the exacerbation of chronic diseases (cardiovascular or respiratory) it causes may result in an increased demand for drugs (Hassan et al., 2024). Reducing exposure could therefore reduce both the health effects and the need for medication.

In addition, there are already studies (Hadley et al., 2018) containing forms for assessing a patient's exposure to air pollution in the clinical environment, as well as proposals for individual interventions to reduce exposure.

Conclusion

The issue of air pollution does not appear directly in the requirements describing the medical curriculum at universities in Poland. The topic is mentioned during specialization training in selected fields of medicine, but remains scarce and probably of little importance to the overall training course. It should be considered whether, given the significant health burden resulting from exposure to air pollution in Poland, actions should be taken to make students and doctors more knowledgeable on this subject. This could reduce to some extent the negative impact of air pollution on the health of Polish residents.

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