Authors

[1]**MOHD IMRAN**, Center for Health Research, Northern Border University, Arar 73213, Saudi Arabia. (E-mail: imran.pchem@gmail.com; ORCID: 0000-0002-6064-1040)

[2]**RUMAISA HAYAT,** Department of Environmental Science, Integral University, Lucknow 226026, India. (E-mail: r.hyat2020@gmail.com; ORCID: 0009-0008-7982-3531)

[3]**BANDAR THEYAB ALENEZI**, Department of Pharmacology, Faculty of Medicine, Northern Border University, Arar, Saudi Arabia. (E-mail: Bandar.alenezi@nbu.edu.sa; ORCID: 0009-0006-2758-5581)

[4]**NADEEM AHMAD SIDDIQUE**, Department of Pharmaceutical Chemistry, University of Hafr Al Batin, Hafar Al Batin, Kingdom of Saudi Arabia. (E-mail: nasiddique@uhb.edu.sa; ORCID: 0000-0002-1584-4877)

[5]**NEELAM SINGLA**, Department of Pharmacy, Suresh Gyan Vihar University, Jaipur, Rajasthan, India. (E-mail: neelams.singla@gmail.com; ORCID: 0000-0002-3583-7025)

[6*]**ABIDA KHAN**, Center for Health Research, Northern Border University, Arar 73213, Saudi Arabia. (Email: aqua_abkhan@yahoo.com; ORCID: 0000-0001-6186-461X)

Received:15-05-2026
Revised:19-06-2026
Accepted:25-06-2026
Doi:10.1922/ejprd.v34i7s.1581

European Journal of Prosthodontics and Restorative Dentistry (2026) 34(7s), 62-71

From Mines To Medicines: The Role Of Community Pharmacists In Protecting Populations Near Phosphate Mining Sites

Abstract

Phosphate mining is a source of fertilizer production; but particulate matter, silica, fluoride, heavy metals, radionuclides, and other contaminants can be released into the air, water, soil, and food-chain pathways during phosphate extraction, beneficiation, phosphoric acid manufacture, and phosphogypsum disposal. This narrative review outlines the community health impacts of phosphate mining and examines the potential contribution of community pharmacy to the protection of populations of those living near mining and processing sites. The literature was sorted out from PubMed, Scopus, Web of Science, and Google Scholar, primarily from 2015 to 2026, and some former basic works were also selected. Narrative synthesis was conducted on the routes of exposure, priority contaminants, health outcomes, vulnerable groups, and interventions to be offered by the pharmacy. Chronic low-level exposure can occur in communities around the phosphogypsum stacks, phosphogypsum processing plants, tailings, and phosphate mines via inhalation, ingestion, dermal contact, and the food chain. Respiratory disease, renal toxicity, skeletal effects, neurodevelopmental issues, cardiovascular risk, inflammation, oxidative stress, and potential long-term carcinogenic effects are the major health concerns. The young, pregnant women, the elderly, smokers, and those with chronic conditions are especially susceptible. Community pharmacists have the opportunity to assist with risk reduction in the following ways: health education, symptom screening, respiratory care, medication review, antimicrobial stewardship, referral, documentation, follow-up and linkage with primary care and public health services. To enhance surveillance, early detection and protection of communities around mines, the collaboration between pharmacies, primary care, public health authorities and environmental agencies needs to be integrated.

Keywords: Community pharmacy, Phosphate mining, Environmental hazards, Public Health, Pharmaceutical care.

INTRODUCTION

Phosphate mining is an important industry because phosphate rock is the major source of phosphorus used in fertilizer manufacture and world agricultural production. The mining of phosphate rock, however, can produce significant environmental impacts, especially when the extraction, beneficiation, and processing of phosphate rock are not managed properly. The open-pit mining, crushing of the ore, beneficiation, production of phosphoric acid, and disposal of phosphogypsum could change landforms, affect ecosystems, and release contaminants to the air, water, and soil [1-3]. Phosphate mining is not only a problem of ecological degradation, it is also a problem of exposure to the environment. Residents residing in the vicinity of phosphate mines, processing plants, tailings ponds, and phosphogypsum stacks can be exposed to low levels of phosphate over time by inhalation of dust, oral ingestion of contaminated water or food, dermal exposure to contaminated soil or water, and food chain exposure [3,4]. Phosphate mining contamination can have a variety of health impacts, including respiratory, renal, skeletal, neurological, cardiovascular, and carcinogenic effects. The risks identified draw attention to the importance of considering phosphate mining as a social and/or a public health problem, as well as an environmental or industrial problem [3,4].

Community pharmacists are the most accessible health care providers and frequently the first health care professionals seen by patients with respiratory symptoms, chronic diseases, medication-related problems, or concerns related to environmental exposures [5,6]. In the past, the environmental impacts of phosphate mining and phosphogypsum disposal have been considered [2,7], but there has been less discussion about the actual health-system response required in communities near phosphate mines. The contribution that community pharmacy can make is in particular underexplored. Hence, this narrative review primarily focuses on the community health effects of phosphate mining, and the importance of community pharmacy's contribution to the reduction of health risks through various means. This review aims to bring together environmental exposure science and community-based pharmacy practice in a way that will enable a practical approach to enhance health protection in populations exposed in close proximity to phosphate mining and processing operations.

SEARCH METHODOLOGY

A narrative literature review was used to locate and combine the evidence related to community health effects and the potential involvement of community pharmacists in mining-adjacent communities. PubMed, Scopus, Web of Science, and Google Scholar were used in the literature search. The primary search period was from 2015-2026. Selected earlier studies were also added; however, where they contributed to providing key background information or foundational evidence related to phosphate mining, phosphogypsum, environmental contamination, or community health risks.

HEALTH IMPACTS OF PHOSPHATE MINING

The communities near the phosphate mining and processing sites can potentially be exposed via inhalation, ingestion, dermal exposure, and food chain. One of the most significant routes of exposure is through inhalation, since mining dust can be carried long distances by wind. Fine particles can enter deep into the respiratory tract and can contain toxic metals, silica, and radioactive particles [8-12]. Figure 1 shows the major health effects of phosphate mining on humans [3,4,8-12].

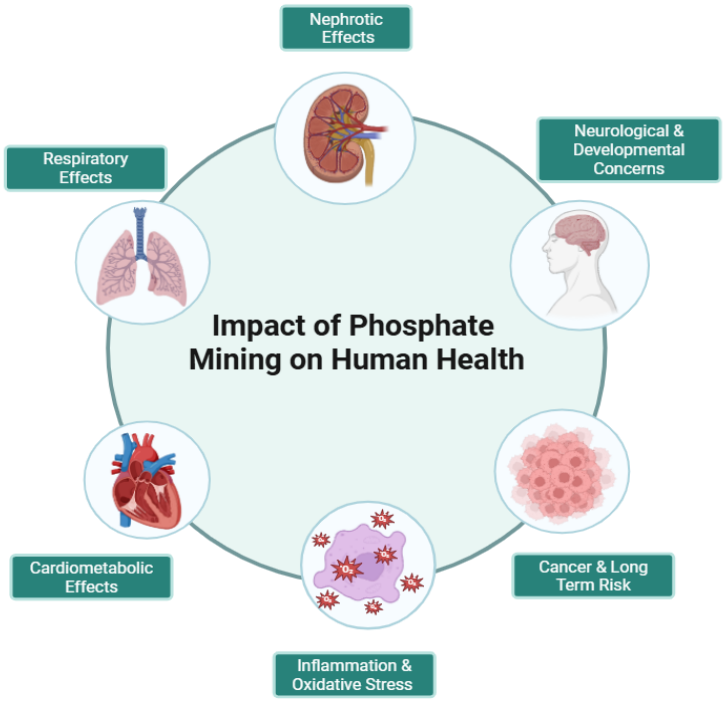

Figure 1. Schematic representation of the major health impacts of phosphate mining on human health.

The adverse health impacts of phosphate mining are associated with several key contaminants, as summarized in Table 1.

Table 1: Priority contaminants associated with phosphate mining and their health impacts

Contaminant category	Specific contaminants	Source/origin	Major health effects
Particulate matter [13]	$PM_{2.5}$, PM_{10}	Mining, drilling, blasting, crushing, transport, and processing activities	Respiratory irritation, airway inflammation, asthma, bronchitis, COPD, reduced lung function, and possible cardiovascular effects
Silica-containing dust [14]	Crystalline silica	Excavation, rock handling, and crushing	Silicosis, pulmonary fibrosis, chronic respiratory disease, and increased lung cancer risk
Trace elements/heavy metals [8]	Cadmium, lead, arsenic, mercury, chromium, uranium, vanadium	Naturally present in phosphate ores and released during mining and processing	Nephrotoxicity, neurotoxicity, skeletal effects, metabolic disorders, cardiovascular effects, developmental toxicity, and carcinogenic risk
Fluoride compounds [14]	Fluoride	Phosphate ore, beneficiation, fertilizer production, wastewater discharge, and contaminated groundwater	Dental fluorosis, skeletal fluorosis, bone pain, joint stiffness, bone deformities, and impaired mobility
Radionuclides [11,15]	Uranium, thorium, radium, radon, and decay products	Naturally occurring radioactive materials in phosphate rock; concentrated in phosphogypsum and processing residues	Ionizing radiation exposure, increased long-term cancer risk, and radiological health concerns
Phosphogypsum waste [12,16]	Mixture of radionuclides, fluoride, trace elements, and heavy metals	By-product of phosphoric acid production; stored in large stacks	Long-term environmental contamination, groundwater pollution, dust dispersion, radon release, and combined chemical-radiological toxicity

THE ROLE OF COMMUNITY PHARMACY IN MINING-ADJACENT SETTINGS

Communities that are near the phosphate mining and processing activities can be impacted by environmental, occupational, social, and health access problems [3,4]. The inhalation of dust, the drinking of contaminated water, exposure to other pollutants such as heavy metals, fluorides and naturally occurring radionuclides can add to respiratory disease, cardiovascular disease risks, kidney toxicity, neurological problems and psychosocial stress [8,11-16]. In addition, there could be socioeconomic instability in the mining-dependent communities, limited access to medical and health care facilities, and greater vulnerability in children, pregnant women, older people, and patients with chronic diseases [17]. In these environments, community pharmacists have the chance to be convenient and first-line healthcare professionals, providing support in every aspect of healthcare: prevention, early detection, patient education, medication optimization, referral, and public health communication.

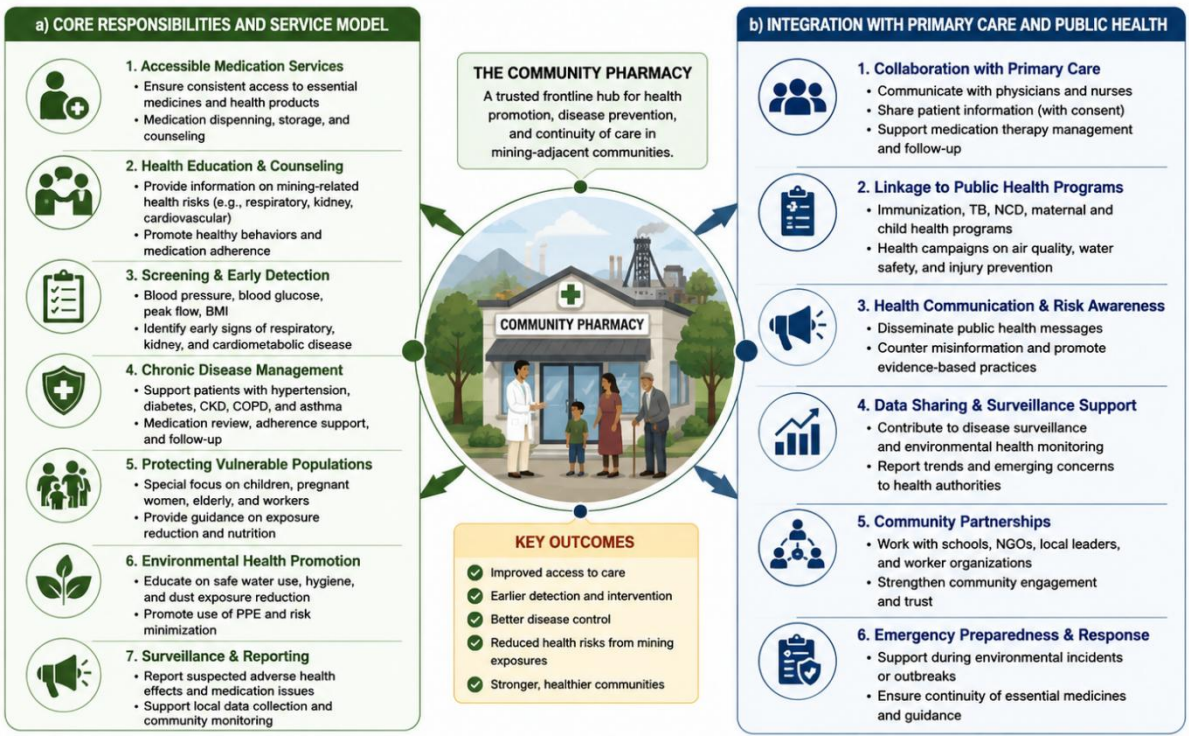

Figure 2: Role of community pharmacy in mining-adjacent settings, highlighting healthcare delivery, disease prevention, environmental health promotion, and integration with primary care and public health systems

Core responsibilities and service model

Community pharmacies in mining-adjacent areas should not be seen as a place of dispensing medicine. They can serve as community-based health access points that offer preventive health care, chronic disease support services, and early detection of environmentally related health issues. Dispensing medications, counseling, and providing minor symptom management, support for adherence, smoking cessation counseling, vaccination services, and basic screening of common chronic conditions like hypertension, diabetes, asthma, and chronic obstructive pulmonary disease (COPD) are all examples of core responsibilities. This is an expanded role in line with the current health promotion and health inequalities reduction focus of the expanding asset-based and community practice model of the pharmacist [5,6,18-20]. This model is especially applicable to phosphate mining communities, where residents can be exposed to low levels of the environment at multiple times and where there is a shortage of specialized health care. Pharmacists can proactively identify patients who have a persistent cough, wheezing, shortness of breath, uncontrolled blood pressure, renal-risk symptoms or medication-related issues and should refer them for medical evaluation if necessary.

Integration with primary care and public health systems

To properly manage health risks associated with mines, there is a need for coordination among community pharmacies, primary healthcare centers, physicians, public health agencies, environmental agencies and community organizations. Community pharmacists are well-positioned to help this integrated approach, identifying common health complaints, making appropriate referrals to medical services, involvement in vaccination and awareness-building programs, and involvement in community health education [21,22]. Pharmacists can also assist in the dissemination of public health messages on reducing dust exposure, smoking cessation, early public health warning signs, and respiratory protection, as well as safe drinking water [23,24]. Environmental risks in mining-adjacent settings are frequently poorly understood by the general public, and are chronic and cumulative in nature, thus making this form of communication valuable [25].

Pharmaceutical care interventions

Pharmaceutical care in communities next to mines should be targeted towards follow-up, preventive, and patient-centered services. Pharmacists have the opportunity to maximize medication utilisation to manage these various chronic conditions, which can be exacerbated by environmental exposures, such as respiratory, cardiovascular, renal, metabolic and neurological [26]. Pharmaceutical care interventions are the measures taken in the course of pharmaceutical care, which include medication review, review of adherence, counseling, disease monitoring, identification of drug-related problems, and referrals to physicians if symptoms worsen or are not controlled [26,27]. Some patients with asthma or COPD may need a review of inhaler use and adherence; patients with hypertension and cardiovascular disease may need a review of blood pressure and medication; and patients with chronic kidney disease or diabetes may need to be advised not to use medications that are harmful to the kidneys and to ensure their laboratory follow-up [28,29].

Screening and referral pathways

Pharmacy-based screening and structured referral pathways can play a key role in the early detection role

for the community pharmacist. In the mining communities, some priorities for screening may be respiratory symptoms, blood pressure, blood glucose, smoking status, medication adherence, and risk factors for chronic cardiopulmonary disease. Pharmacists can also provide assistance with respiratory screening (where feasible) or make a pulmonary function testing referral for high risk patients [24,30,31]. Persistent cough, difficulty breathing, wheezing, chest tightness, frequent infections, tiredness, neurological symptoms or possible exposure-related symptoms should prompt a referral to relevant healthcare facilities. Special consideration should be given to children, pregnant women, older adults, smokers and those with asthma, COPD, cardiovascular disease, diabetes and kidney disease [30,32].

Medication therapy management

Medication Therapy Management is a specific, pharmacist-led service that is aimed at optimizing therapeutic results and minimizing medication related problems. Contains med reconciliation, review of medication and over-the-counter medications, adherence assessment, dose optimization, medication interaction screening and patient education [33,34]. For mining-related communities, Medication Therapy Management is particularly critical for individuals with multiple chronic conditions that are likely taking multiple medications [33-35]. Pharmacists are helpful in detecting self-medication, overuse of antibiotics, overuse of non-steroidal anti-inflammatory drugs, incorrect use of inhalers, when symptoms are uncontrolled despite treatment and when drug interactions are possible. They can also collaborate with doctors to optimize treatment and timely referrals when patient symptoms are suspected to be associated with the process of disease or environmental exposure [24,36,37].

Medication safety and antimicrobial stewardship

Community pharmacists have a key role in medication safety. Pharmacists can identify prescription errors, provide patients with counselling on proper medication use, recognize adverse drug reactions, and minimize preventable medication-related problems. Pharmacists may be the first point of contact in a community with poor access to care within the healthcare system for patients presenting with a respiratory complaint, gastrointestinal complaint, fever, skin irritation or minor illness. So, safe triage and referral is key [26,34,38,39]. A further role that community pharmacists play in antimicrobial stewardship is to dissuade inappropriate antibiotic prescribing, educate patients on the issue of AMR and encourage evidence-based prescribing. This is especially relevant when there is a risk of symptoms relating to the recurrent respiratory system due to dust and pollution being confused with infectious illness, resulting in inappropriate antibiotic use [36,40,41].

Respiratory care optimization

Dust exposure, particulate matter, smoking and pre-existing respiratory disease could be additive in influencing respiratory outcomes and respiratory care is a priority in phosphate-mining communities. A pharmacist can assist respiratory care by checking inhaler technique, tracking adherence to controller medicines, looking for inadequate symptom control, providing counseling on trigger avoidance and smoking cessation. Pharmacist-led respiratory interventions have been proven to enhance recognition and management of chronic respiratory illnesses like asthma and COPD [24,42]. If patients are using their rescue inhaler regularly, if their symptoms occur at night, if they have had more than one exacerbation, if they find it difficult to use their inhalers properly, or if they still have breathlessness, they should be referred for a review. The pharmacist can also work with patients to help them understand how to minimize exposure to dust indoors, how to avoid exposure to secondhand smoke and how to seek medical care if symptoms related to breathing get worse or last longer [43,44].

Health promotion and environmental health education

Smoking Cessation Services, Vaccination Services, Nutrition Counseling, Lifestyle Modification Advice, and Disease Prevention Education, are all areas of health promotion that community pharmacists can participate in [45]. Within the mining environment, environmental health education is also important for health promotion. Pharmacists may deliver simple and practical messages about reducing exposure to dust, sources of safe water, signs that may require medical evaluation and the protection of vulnerable family members [46,47]. Health education should reflect cultural appropriateness and understanding, and be action oriented. In addition, pharmacists can also join community awareness campaigns in partnership with public health agencies, schools, community leaders, and environmental agencies [48,49].

Patient counseling

Medication adherence, understanding and self-management are all important areas that can be enhanced with patient counseling. It is important for a pharmacist to educate patients on proper dosage amounts, timing, storage, side effects, drug interactions, and signs of concern that should be referred to a medical professional [50]. For the mining adjacent communities, counseling should also include information on the potential impact of environmental exposures on chronic disease management [26,51]. For instance, patients with asthma or COPD should be instructed to use their inhaler, avoid exposure to dust and smoke and emphasize the need for follow-up if symptoms worsen. Those with hypertension, diabetes, kidney disease and cardiovascular disease should be educated to take care, monitor regularly and not take medicines which are harmful. Specific counseling should be provided for pregnant women, caregivers of children, and older adults, who may be at increased risk from environmental contaminants [29,52,53].

Documentation and follow-Up

Continuity of care and evaluation of the outcomes of pharmacy interventions require documentation and follow up. Pharmacists should record screening findings, counselling given, medication problems and follow-up consequences, referrals made and outcomes. The

documentation of such issues can aid in the identification of a pattern of respiratory complaints, uncontrolled chronic disease or suspected exposure related health concerns in the mining adjacent community [54-56]. In many resource-limited health-care environments, however, documentation is still problematic. Hence, basic systems of recording in the pharmacy, referral and linkage with primary care services could help to enhance continuity of care. Pharmacy observations may also contribute to public health surveillance and provide insights into community health needs when aggregated over time, and particularly when used as a tool to assist in understanding how new health needs emerge in communities impacted by phosphate mining [54,57].

DISCUSSION

This narrative review emphasizes that phosphate mining is more than an industrial and environmental problem; it is a community health problem that must be addressed by an integrated health-system response. While phosphate rock continues to be a vital source of phosphorus, its extraction, beneficiation, phosphoric acid manufacture and phosphogypsum disposal can create complicated environmental issues if not managed properly, yet these activities continue to be of critical importance in agriculture [1-3]. The review findings presented in this report suggest that exposure to low levels can occur repeatedly from inhalation, ingestion, dermal contact, and through the food-chain in the communities directly adjacent to phosphate mines, processing facilities, tailing ponds, and phosphogypsum stacks [3,4]. Phosphate mining is a relevant public health issue as it is a chronic and cumulative exposure that can be an issue of health concern especially in communities where environmental monitoring, infrastructure and healthcare services are weak.

One of the main issues is the variety of contaminants brought by phosphate mining and processing. The dust and particulate matter generated through the process of drilling, blasting, excavation, crushing, transporting and processing substances can be dispersed beyond the mining operations and inhaled by those living in the vicinity. The fine particles can enter the respiratory system to a great depth and can also contain radioactive particles, toxic metals and silica [8,9,12]. This aids the plausibility of respiratory outcomes, including airway irritation, bronchitis, exacerbation of asthma, and worsening of COPD and decreasing lung function. One type of dust that is especially relevant to consider is silica dust, particularly crystalline silica, which is reported to be linked to chronic respiratory disease, silicosis and pulmonary fibrosis, as well as an increased risk of lung cancer [13]. Most silica-related data are occupational, but may still be biologically relevant in the community setting where dust control is inadequate and where silica exposure occurs outside the workplace.

Inhalation is not the only route of inhalation exposure that is hazardous. Cadmium, lead, arsenic, mercury, chromium, uranium, vanadium and other elements may be present in phosphate ores and can be introduced to soil, water, plants and to human pathways [8]. These contaminants have been linked to the risk of nephrotoxicity, neurotoxicity, developmental toxicity, cardiovascular effects, skeletal effect and carcinogenic effects. Groundwater contamination is especially significant as it may pollute water for drinking, agricultural and domestic purposes, due to contamination from mining effluents, tailings and phosphogypsum leachates [4]. Fluoride exposure may also result in dental and skeletal fluorosis, bone pain and stiffness of joints, and overall decreased mobility particularly in areas where safe water systems are not available [14]. These pathways illustrate that the phosphate mining can impact health in many ways and not one pollutant or pathway.

Phosphogypsum is one of the most persistent issues as it is chemically as well as radiologically hazardous. Phosphogypsum can have radioactive materials, fluoride, trace elements and heavy metals as contaminants, and can cause dust releases, leaching, runoff, groundwater pollution and radon emissions when stored in high stacks [12,16]. Uranium, thorium, radium, radon and decay products of radon can pose long-term radiological risk, such as enhanced risk of cancer over lifetime for exposed people [11,15]. Such worries underscore the importance of long-term monitoring of contamination in the air, soil, and food-chain in and around phosphate mines and processing plants.

The review also highlights the unequal distribution of exposure risk. Pediatric and pregnant women, older adults, smokers and individuals with asthma, COPD, cardiovascular disease, diabetes, kidney disease may be more likely to be affected by mining-related contaminants [17,32]. Children are considered more vulnerable due to their immature respiratory and neurological systems and higher exposure due to their smaller body size. Special care should be given for pregnant women as heavy metals and air pollutants can have impacts on the growth and development of fetuses. Chronic disease conditions (e.g., respiratory, cardiovascular, renal or metabolic) may deteriorate in older adults and patients. Thus, community health interventions should focus not solely on population-level interventions, but focus on vulnerable populations.

In this context, community pharmacy could offer a viable and under-utilised platform for risk reduction. Community pharmacists can be an accessible healthcare provider and could be one of the first professionals that a resident may see if they have symptoms relating to the respiratory system, a chronic illness complaint, medication related problems, or concerns regarding environmental exposure [5,6]. Their responsibilities in mining-adjacent communities should not end with the provision of medicines, but should also involve health education, screening for symptoms, review of medications, support with medication adherence, smoking cessation, vaccination, referrals and linkage to primary care. This expanded role falls in line with asset based and community oriented pharmacy practice models [18].

Pathways for screenings and referrals undertaken by the pharmacist are particularly important when it comes to

early detection of risk factors for respiratory and cardiometabolic conditions. Patients with persistent cough, wheezing, breathlessness, blood pressure, blood glucose, smoking status, poor adherence to medications and uncontrolled chronic disease should be considered for medical evaluation [24,30,31]. Additionally, pharmacists have the opportunity to optimise the management of respiratory care, which includes assessing inhaler use, assisting with adherence to controller medicines, avoiding triggers, and smoking cessation [42,44]. These interventions can help to lower the symptom burden and enhance early referral in communities with dust and air pollutants.

Medication therapy management and medication safety are also significant due to the fact that environmentally vulnerable populations often suffer from multiple chronic diseases, and may be taking multiple prescription and non-prescription medicines [33,34]. The pharmacist can detect inappropriate self-medication, excess NSAID use in patients at risk for kidney damage, incorrect inhaler technique, lack of control of symptoms, drug interactions, and inappropriate antibiotic use. Antimicrobial stewardship is relevant in particular as the symptoms of pollution can be taken for signs of infection, causing inappropriate antibiotic treatment [36,40].

Lastly, documentation and follow up will be vital if pharmacy services are to be a part of the wider public health protection. Documentation is also frequently poor in resource-limited settings, but basic records of symptoms, screening, counselling, referrals and follow-up results created in the pharmacy can facilitate continuity of care [54]. Pharmacy aggregation observations can also help with public health surveillance that is used to monitor chronic diseases that are not controlled, or common respiratory conditions, or new community health needs over time [57]. The role of the pharmacy is supportive and collaborative, however, and should not be considered as a replacement for environmental regulation, exposure monitoring or primary health care. Practical pharmacy based protocols should be developed for mining-adjacent communities to assess for early detection, referral, medication safety, and community health outcomes and should be evaluated for future use.

CONCLUSION

Phosphate mining is vital for the production of fertilizers, but it can create a variety of environmental by-products which may affect communities in the vicinity via air, water, soil and food-chain routes. The exposures can lead to respiratory, renal, skeletal, neurological, cardiovascular, developmental and chronic cancer effects, especially in susceptible individuals. Community pharmacists can aid in risk reduction by offering health education, symptom screening, medication review, respiratory care, antimicrobial stewardship, referral, documentation and follow-up. Collaboration across all partners pharmacies, primary care, public health/environmental agencies is needed to improve surveillance and keep mining communities safe.

Acknowledgement
The authors extend their appreciation to Northern Border University, Saudi Arabia, for supporting this work through project number (NBU-CRP-2026-2043).

Funding
Nil

Conflict Of Interests
The authors declare that there are no competing interests.

References

1. Geissler B, Hermann L, Mew MC, Steiner G. Striving toward a circular economy for phosphorus: the role of phosphate rock mining. Minerals. 2018;8(9):395. doi:10.3390/min8090395.
2. Reta G, Dong X, Li Z, Su B, Hu X, Bo H, Yu D, Wan H, Liu J, Li Y, Xu G, Wang K, Xu S. Environmental impact of phosphate mining and beneficiation: review. Int J Hydrol. 2018;2(4):424-31. doi:10.15406/ijh.2018.02.00106.
3. Silva LFO, Oliveira MLS, Crissien TJ, Santosh M, Bolivar J, Shao L, Dotto GL, Gasparotto J, Schindler M. A review on the environmental impact of phosphogypsum and potential health impacts through the release of nanoparticles. Chemosphere. 2022 Jan;286:131513. doi:10.1016/j.chemosphere.2021.131513.
4. Hamed Y, Gentilucci M, Mokadem N, Khalil R, Ayadi Y, Hadji R, Elaloui E. Assessment and mitigation of groundwater contamination from phosphate mining in Tunisia: geochemical and radiological analysis. Hydrology. 2024;11(6):84. doi:10.3390/hydrology11060084.
5. Valliant SN, Burbage SC, Pathak S, Urick BY. Pharmacists as accessible health care providers: quantifying the opportunity. J Manag Care Spec Pharm. 2022 Jan;28(1):85-90. doi:10.18553/jmcp.2022.28.1.85.
6. Hedima EW, Okoro RN. Primary health care roles of community pharmacists in low- and middle-income countries: a mixed methods systematic review. BMC Health Serv Res. 2025;25:1269. doi:10.1186/s12913-025-13387-0.
7. Chernysh Y, Yakhnenko O, Chubur V, Roubík H. Phosphogypsum recycling: a review of environmental issues, current trends, and prospects. Appl Sci. 2021;11(4):1575. doi:10.3390/app11041575.
8. Al-Hwaiti M, Al Kuisi M, Saffarini G, Alzughoul K. Assessment of elemental distribution and heavy metals contamination in phosphate deposits: potential health risk assessment of finer-grained size fraction. Environ Geochem Health. 2014 Aug;36(4):651-63. doi:10.1007/s10653-013-9587-y.
9. Saadaoui E, Ghazel N, Ben Romdhane C, Massoudi N. Phosphogypsum: potential uses and problems: a review. Int J Environ Stud. 2017;74(4):558-67. doi:10.1080/00207233.2017.1330582.
10. Omri N, Souissi R, Souissi F, Gleyzes C, Zaaboub N, Abderrazak H, Donard OFX, Rddad L. Rare earth elements in phosphate ores and industrial by-products: geochemical behavior, environmental risks, and

recovery potential. Minerals. 2025;15(12):1232. doi:10.3390/min15121232.
11. Mphaga KV, Rathebe PC. Environmental radioactivity associated with mining in Africa: sources, levels, and health risks: a systematic review. Int J Environ Health Res. 2026 Jan 29:1-22. doi:10.1080/09603123.2026.2621063.
12. Pliaka M, Gaidajis G. Potential uses of phosphogypsum: a review. J Environ Sci Health A Tox Hazard Subst Environ Eng. 2022;57(9):746-63. doi:10.1080/10934529.2022.2105632.
13. Setu S, Strezov V. Impacts of non-ferrous metal mining on soil heavy metal pollution and risk assessment. Sci Total Environ. 2025;969:178962. doi:10.1016/j.scitotenv.2025.178962.
14. Al-Nuzal SMD. Environmental impact of radionuclides and inorganic chemicals from Al-Qaim fertilizers complex, Iraq. Iraqi Bulletin of Geology and Mining. 2017;(7):93-111.
15. Arhouni FE, Abdo MAS, Ouakkas S, Boukhair A. Uranium in Moroccan phosphate rock and derivatives: occurrence, redistribution, and radiological considerations. Chemosphere. 2025;392:144755. doi:10.1016/j.chemosphere.2025.144755.
16. Grzywa-Celińska A, Krusiński A, Mazur J, Szewczyk K, Kozak K. Radon: the element of risk. The impact of radon exposure on human health. Toxics. 2020;8(4):120. doi:10.3390/toxics8040120.
17. Jain P, Kaushik R. Discerning the influence of mining activity on the socio-economic determinants of health. Discov Public Health. 2026;23:284. doi:10.1186/s12982-026-01606-w.
18. Astbury J, Schafheutle E, Brown J, Cutts C. The current and potential role of community pharmacy in asset-based approaches to health and wellbeing: a qualitative study. Int J Clin Pharm. 2021;43(5):1257-64. doi:10.1007/s11096-021-01244-z.
19. Foster AA, Daly CJ, Logan T, Logan R, Jarvis H, Croce J, Jalal Z, Trygstad T, Bowers D, Clark B, Moore S, Jacobs DM. Addressing social determinants of health in community pharmacy: innovative opportunities and practice models. J Am Pharm Assoc. 2021;61(5):e48-54. doi:10.1016/j.japh.2021.04.022.
20. Taylor S, Cairns A, Glass BD. Expanded practice in rural community pharmacy: a macro-, meso- and micro-level perspective. Rural Remote Health. 2021;21:6158. doi:10.22605/RRH6158.
21. Mammen MV, Anand A, Suman A, Kumar A, Singh DP. Empowering community health: the role of pharmacy in strengthening local self-governance in India. Lex Localis - Journal of Local Self-Government. 2025;23(S5):414-28. doi:10.52152/801249.
22. Satria MA. Long term health impacts of mining activities: toward community based environmental and public health interventions. Jurnal Riset Kualitatif dan Promosi Kesehatan. 2023;2(2):118-30. doi:10.61194/jrkpk.v2i2.669.
23. Agomo C, Udoh A, Kpokiri E, Osuku-Opio J. Community pharmacists' contribution to public health: assessing the global evidence base. Clin Pharm. 2018;10(4). doi:10.1211/PJ.2018.20204556.
24. Fathima M, Naik-Panvelkar P, Saini B, Armour CL. The role of community pharmacists in screening and subsequent management of chronic respiratory diseases: a systematic review. Pharm Pract (Granada). 2013;11(4):228-45. doi:10.4321/S1886-36552013000400008.
25. Chanda-Kapata Pascalina. Public health and mining in East and Southern Africa: a desk review of the evidence. Harare: Regional Network for Equity in Health in East and Southern Africa; 2020 Apr. EQUINET Discussion Paper 121. Available from: https://equinetafrica.org/sites/default/files/uploads/documents/EQ%20Diss121%20Mining%20and%20health%20April2020.pdf (Accessed on July 1, 2026)
26. Eldooma I, Maatoug M, Yousif M. Outcomes of pharmacist-led pharmaceutical care interventions within community pharmacies: narrative review. Integr Pharm Res Pract. 2023;12:113-26. doi:10.2147/IPRP.S408340.
27. Newman TV, San-Juan-Rodriguez A, Parekh N, Swart ECS, Klein-Fedyshin M, Shrank WH, Hernandez I. Impact of community pharmacist-led interventions in chronic disease management on clinical, utilization, and economic outcomes: an umbrella review. Res Social Adm Pharm. 2020;16(9):1155-65. doi:10.1016/j.sapharm.2019.12.016.
28. Hall RK, Kazancıoğlu R, Thanachayanont T, Wong G, Sabanayagam D, Battistella M, Ahmed SB, Inker LA, Barreto EF, Fu EL, Clase CM, Carrero JJ. Drug stewardship in chronic kidney disease to achieve effective and safe medication use. Nat Rev Nephrol. 2024;20(6):386-401. doi:10.1038/s41581-024-00823-3.
29. Jia X, Zhou S, Luo D, Zhao X, Zhou Y, Cui Y. Effect of pharmacist-led interventions on medication adherence and inhalation technique in adult patients with asthma or COPD: a systematic review and meta-analysis. J Clin Pharm Ther. 2020;45(5):904-17. doi:10.1111/jcpt.13126.
30. Fathima M, Saini B, Foster JM, Armour CL. Community pharmacy-based case finding for COPD in urban and rural settings is feasible and effective. Int J Chron Obstruct Pulmon Dis. 2017;12:2753-61. doi:10.2147/COPD.S145073.
31. Motlohi NF, Wiafe E, Mensah KB, Padayachee N, Petrus R, Bangalee V. A systematic review of the role of community pharmacists in the prevention and control of cardiovascular diseases: the perceptions of patients. Syst Rev. 2023;12:160. doi:10.1186/s13643-023-02338-7.
32. Schraufnagel DE, Balmes JR, Cowl CT, De Matteis S, Jung SH, Mortimer K, Perez-Padilla R, Rice MB, Riojas-Rodriguez H, Sood A, Thurston GD, To T, Vanker A, Wuebbles DJ. Air pollution and noncommunicable diseases: a review by the Forum of International Respiratory Societies' Environmental Committee, part 2: air pollution and organ systems. Chest. 2019;155(2):417-26. doi:10.1016/j.chest.2018.10.041.
33. Salmasi S, Tsao NW, Li K, Shaske JN, Marra CA, Lynd LD. Characterization of pharmacist-based medication management services in a community

pharmacy. Res Social Adm Pharm. 2020;16(2):178-82. doi:10.1016/j.sapharm.2019.04.051.
34. Abilash YD, Geetha P. Medication therapy management amid community pharmacist. Int J Health Sci. 2022;6(S1):8450-6. doi:10.53730/ijhs.v6nS1.6841.
35. Almodóvar AS, Nahata MC. Associations between chronic disease, polypharmacy, and medication-related problems among Medicare beneficiaries. J Manag Care Spec Pharm. 2019;25(5):573-7. doi:10.18553/jmcp.2019.25.5.573.
36. Raju R, Srinivas SC, Siddalingegowda SM, Vaidya R, Gharat M, Kumar TMP. Community pharmacists as antimicrobial resistance stewards: a narrative review on their contributions and challenges in low- and middle-income countries. J Pharm Pharm Sci. 2024;27:12721. doi:10.3389/jpps.2024.12721.
37. Shareef J, Sridhar SB, Al Naqbi SH, Bakshi AI. Beyond pain relief: a cross-sectional study on NSAID prescribing, polypharmacy, and drug interaction risks in community pharmacies. Healthcare (Basel). 2025;13(24):3264. doi:10.3390/healthcare13243264.
38. Han JH, Heo KN, Han J, Lee MS, Kim SJ, Min S, Ah YM, Lee JY. Analysis of medication errors reported by community pharmacists in the Republic of Korea: a cross-sectional study. Medicina (Kaunas). 2023;59(1):151. doi:10.3390/medicina59010151.
39. Curley LE, Moody J, Gobarani R, Aspden T, Jensen M, McDonald M, Shaw J, Sheridan J. Is there potential for the future provision of triage services in community pharmacy? J Pharm Policy Pract. 2016;9:29. doi:10.1186/s40545-016-0080-8.
40. Ashiru-Oredope D, Doble A, Thornley T, Saei A, Gold N, Sallis A, McNulty CAM, Lecky D, Umoh E, Klinger C. Improving management of respiratory tract infections in community pharmacies and promoting antimicrobial stewardship: a cluster randomised control trial with a self-report behavioural questionnaire and process evaluation. Pharmacy (Basel). 2020;8(1):44. doi:10.3390/pharmacy8010044.
41. Abelenda-Alonso G, Satorra P, Marí-Dell'Olmo M, Tebé C, Padullés A, Vergara A, Gudiol C, Pujol M, Carratalà J. Short-term exposure to ambient air pollution and antimicrobial use for acute respiratory symptoms. JAMA Netw Open. 2024;7(9):e2432245. doi:10.1001/jamanetworkopen.2024.32245.
42. Patil CM, Dsouza PD, Chitralu SPP, Koujalagi VA, Swamy AHV, Nyamagoud SB. Optimizing respiratory care: clinical pharmacist interventions in respiratory tract infection management at a tertiary teaching hospital. Monaldi Arch Chest Dis. 2026;96:3337. doi:10.4081/monaldi.2025.3337.
43. Tiotiu AI, Novakova P, Nedeva D, Chong-Neto HJ, Novakova S, Steiropoulos P, Kowal K. Impact of air pollution on asthma outcomes. Int J Environ Res Public Health. 2020;17(17):6212. doi:10.3390/ijerph17176212.
44. Makhinova T, Walker BL, Gukert M, Kalvi L, Guirguis LM. Checking inhaler technique in the community pharmacy: predictors of critical errors. Pharmacy (Basel). 2020;8(1):6. doi:10.3390/pharmacy8010006.
45. Loh P, Chua SS, Karuppannan M. The extent and barriers in providing pharmaceutical care services by community pharmacists in Malaysia: a cross-sectional study. BMC Health Serv Res. 2021;21:822. doi:10.1186/s12913-021-06820-7.
46. Brown TJ, Todd A, O'Malley CL, Moore HJ, Husband AK, Bambra C, Kasim A, Sniehotta FF, Steed L, Summerbell CD. Community pharmacy interventions for public health priorities: a systematic review of community pharmacy-delivered smoking, alcohol and weight management interventions. Public Health Res. 2016;4(2):1-162. doi:10.3310/phr04020.
47. Al-Horani RA, Ayyad A. Educating the public about toxic chemicals that we unknowingly consume: a potential important role for the practicing pharmacists. J Am Pharm Assoc. 2024;64(2):355-63. doi:10.1016/j.japh.2023.11.007.
48. DiPietro Mager NA, Bright D. Advancing public health through community pharmacy practice. Pharmacy (Basel). 2023;11(2):56. doi:10.3390/pharmacy11020056.
49. Steed L, Sohanpal R, Todd A, Madurasinghe VW, Rivas C, Edwards EA, Summerbell CD, Taylor SJC, Walton R. Community pharmacy interventions for health promotion: effects on professional practice and health outcomes. Cochrane Database Syst Rev. 2019;12(12):CD011207. doi:10.1002/14651858.CD011207.pub2.
50. Kasar PM, Salunke CS, Patil KP. Patient counseling: role of pharmacist. Asian J Res Pharm Sci. 2023;13(3):255-8. doi:10.52711/2231-5659.2023.00044.
51. Guo SE, Chi MC, Hwang SL, Lin CM, Lin YC. Effects of particulate matter education on self-care knowledge regarding air pollution, symptom changes, and indoor air quality among patients with chronic obstructive pulmonary disease. Int J Environ Res Public Health. 2020;17(11):4103. doi:10.3390/ijerph17114103.
52. Khan MMT, Sklar L. Editorial: environmental contaminants in aquatic systems and chemical safety for environmental and human health, volume II. Front Public Health. 2023;11:1157834. doi:10.3389/fpubh.2023.1157834.
53. Wang T, Kang HC, Chen CC, Lai TS, Huang CF, Wu CC. The effects of pharmacist-led medication therapy management on medication adherence and use of non-steroidal anti-inflammatory drug in patients with pre-end stage renal disease. Patient Prefer Adherence. 2024;18:267-74. doi:10.2147/PPA.S436952.
54. Demsash AW, Kassie SY, Dubale AT, Chereka AA, Ngusie HS, Hunde MK, Emanu MD, Shibabaw AA, Walle AD. Health professionals' routine practice documentation and its associated factors in a resource-limited setting: a cross-sectional study. BMJ Health Care Inform. 2023;30(1):e100699. doi:10.1136/bmjhci-2022-100699.
55. Hamada N, Quintana Bárcena P, Maes KA, Bugnon O, Berger J. Clinical pharmacy activities documented (ClinPhADoc): development, reliability and acceptability of a documentation tool for community pharmacists. Pharmacy (Basel). 2019;7(4):162. doi:10.3390/pharmacy7040162.

56. Rivera J, Shcherbakova N, Vala C, Capoccia K. Community pharmacists' interventions and documentation during medication therapy management encounters delivered face-to-face versus via telephone: the devil is in the details. Res Social Adm Pharm. 2020;16(10):1447-51. doi:10.1016/j.sapharm.2019.12.020.

57. Jambrina AM, Rams N, Rius P, Perelló M, Gironès M, Pareja C, Pérez-Cano FJ, Franch À, Rabanal M. Creation and implementation of a new sentinel surveillance model in pharmacy offices in southern Europe. Int J Environ Res Public Health. 2022;19(14):8600. doi:10.3390/ijerph19148600.