Original article

Health Impacts of Dye Factory Effluents on Children Under Five in Uttarkhan, Dhaka: A Cross-Sectional Study

Md. Moyeedur Rahman[1], Bulbul Hossain Shuvo[2], Rokya Sharmin Huda Fariha[3]

Abstract

Background: Rapid industrialization in Dhaka, particularly the growth of unregulated dye factories, has led to increased environmental pollution, raising serious public health concerns. Children under five are especially vulnerable to pollution-related illnesses due to their immature immune systems and close contact with contaminated surroundings. *Objectives:* This study investigates the relationship between proximity to dye factory effluents and the prevalence of respiratory, gastrointestinal, and dermatological symptoms among children under five in Uttarkhan, Dhaka. *Materials and methods:* A cross-sectional study was conducted for 12 months (from 1st January to 31st December 2018) in two localities—Munda and Polartek—within the ward No. 4 of Uttarkhan Thana, Dhaka city. A total of 200 households, each with at least one child under five years of age, were surveyed using a semi-structured questionnaire. *Results:* Most respondents were females (94.5%) aged between 18–39 years (91.5%) and lived in overcrowded conditions (average 7.45 persons per room). A large majority (97%) used deep tube wells for daily water. Respiratory symptoms—including nasal discharge (36.5%), cough (29.0%), and wheezing (14.0%)—were most prevalent among those living within 100 yards of the river. Surprisingly, gastrointestinal and dermatological symptoms such as diarrhea (9.5%), vomiting (10.0%), rash (10.0%), and skin ulceration (8.5%) were more frequently reported by residents living more than 200 yards away. *Conclusion:* Proximity to dye-contaminated rivers is associated with a higher prevalence of respiratory symptoms in young children, while other symptom patterns suggest multiple environmental risk factors. These findings highlight the urgent need for environmental health interventions and stricter regulation of industrial waste management in urban residential zones.

Keywords: Gastrointestinal symptoms, respiratory symptoms, dermatological symptoms, dye factory wastewater.

Introduction:

Environmental pollution has become one of the most pressing public health concerns in rapidly urbanizing cities of the developing world[1]. In Dhaka, the capital of Bangladesh, industrial expansion—especially unregulated dyeing and textile industries—has dramatically reshaped both the landscape and the health profile of the vulnerable populations[2]. Among these, children under the age of five are particularly at risk due to their developing immune systems, frequent contact with the environment, and higher consumption of water and food per body weight compared to adults[3]. In many low-income neighborhoods of Dhaka,

Address of correspondence: Dr. Md. Moyeedur Rahman, Assistant Professor, Department of Epidemiology, Institute of Epidemiology, Disease Control & Research (IEDCR), Dhaka-1212. E-mail: dr.moyeed@gmail.com

1. Dr. Md. Moyeedur Rahman, Assistant Professor, Department of Epidemiology, Institute of Epidemiology, Disease Control & Research (IEDCR), Dhaka.
2. Dr. Bulbul Hossain Shuvo, Associate Professor (CC), Department of Community Medicine, Bashundhara Ad-din Medical College, Dhaka
3. Dr. Rokya Sharmin Huda Fariha, Assistant Register (Medicine), Monowara Shikder Medical College & Hospital, Dhaka.

rivers have become toxic lifelines—visibly flowing with vibrant hues from textile dyes and chemically infused waste[4]. The waterways, once vital sources of livelihood and irrigation, are now laden with untreated industrial discharge that seeps into surrounding land, contaminates groundwater, and pollutes the air[5]. Among the affected communities, residents of the Uttarkhan Thana, specifically in areas such as Munda and Polartek of ward No. 4, live in dangerously close proximity to these contaminated waterways, often without adequate awareness of the risks they face. Despite the growing alarm over industrial pollution in Dhaka's peripheral zones, very little is known about how environmental exposures are impacting the health of the most susceptible—children under five[4]. This age group is particularly prone to developing gastrointestinal, respiratory, and dermatological symptoms when exposed to toxic chemicals, unsanitary living conditions, or polluted water sources. Respiratory infections, diarrhea, and skin diseases continue to be leading causes of morbidity and mortality in Bangladeshi children, and yet the environmental determinants of these illnesses remain inadequately explored in context-specific studies[6]. This study seeks to fill that gap by focusing on the lived realities of families residing near dye factory effluents in the Uttarkhan area. It examines how close proximity to polluted rivers correlates with the prevalence of various childhood symptoms, while also exploring socio-demographic variables, water use patterns, and household living conditions[7]. By surveying 200 households with at least one child under the age of five, this research offers a micro-level view into a macro-scale problem—how industrial pollution silently erodes community health[8]. What makes this investigation particularly compelling is its dual focus: not only does it analyze statistical associations between environmental exposure and illness, but it also paints a socio-environmental portrait of the communities most affected[9]. The findings of this study are grounded in real voices and real conditions—crowded homes, water fetched from deep tube wells, mothers who manage households while tending to sick children, and neighborhoods that have adjusted to the foul smells and colorful toxins as part of daily life. Furthermore, the study draws attention to an often-overlooked dimension of environmental justice: how poverty, gender, and education intersect to shape vulnerability. With 94.5% of the respondents being women, mostly homemakers, and 75.5% having at least secondary education, the data also speak to a relatively informed but economically constrained population. Despite moderate levels of education and water access, families still report high rates of illness, suggesting that deeper structural factors—like unregulated industry and urban planning failures—play a more decisive role in determining child health outcomes. In highlighting the spatial relationship between health symptoms and environmental exposure, this study underscores an urgent need for integrated public health and environmental policies[10]. Clean water access, stricter industrial waste regulation, and improved housing infrastructure must go hand in hand with community education and early childhood healthcare services[11]. Without a multi-sectoral approach, the invisible burden borne by children living on the fringes of industrial zones will only continue to grow. Ultimately, this research is not just about the numbers or symptoms—it is about the visibility [12]. It brings into focus the forgotten corners of the city where children cough, itch, and fall ill in the shadows of the economic growth [13]. It is about demanding accountability in places where pollution has become so normalized that even illness feels inevitable. And it is about giving voice to those whose health has become the silent collateral damage of the unregulated development [14].

Materials and methods

This was a community-based cross-sectional study conducted in two selected localities—Munda and Polartek—within the ward No. 4 of the Uttarkhan Thana, located in the northern part of Dhaka city, Bangladesh, for 12 months (1st January to 31st December 2018). These areas are in proximity to dye factories and heavily polluted river systems, making them relevant for assessing environmental health risks among children. The study population comprised households with at least one child under five years of age. A total of 200 households were selected using purposive sampling to ensure representation from different distances relative to the river: less than 100 yards, between 100 and 200 yards, and more than 200 yards. Respondents were typically the mothers or primary caregivers of the children and were interviewed in person. Inclusion criteria included residency in the study area for at least six months and having at least one child aged 0–59 months.

Data Collection Tools and Techniques

Data were collected using a semi-structured pre-tested questionnaire administered through face-to-face interviews. The questionnaire was developed in English, translated into Bengali, and then back-translated to ensure accuracy. It consisted of the following components:

- Socio-demographic data (age, sex, education, religion, marital status, occupation).

- Wealth categorization (based on household assets and income, self-reported).

- Environmental and water-use information (source of water, distance from river, agricultural involvement).

- Child-specific data (age, sex, number of children under five).

- Health symptoms (respiratory, gastrointestinal, dermatological symptoms in the past 30 days).

Variables

- Independent Variable: Distance from the river (categorized as <100 yards, 100–200 yards, >200 yards).

- Dependent Variables: Presence of specific child symptoms—respiratory (e.g., nasal discharge, cough), gastrointestinal (e.g., diarrhea, vomiting), and dermatological (e.g., rash, skin ulcers).

Data Analysis

Data were entered into Microsoft Excel and analyzed using descriptive statistics. Results were presented in frequencies, percentages, and means ± standard deviations. Associations between distance from the river and health symptoms were summarized in tables and visually interpreted to identify trends.

Ethical Considerations

Verbal informed consent was obtained from all participants before data collection. Participants were assured of confidentiality and informed that their participation was voluntary. No personal identifiers were recorded. The study was conducted in adherence to ethical principles for research involving human subjects.

Result:

The study was conducted in two localities—Munda and Polartek—within the ward No. 4 of Uttarkhan Thana, Dhaka city. A total of 200 households were surveyed, each with at least one child under the age of five. The study aimed to collect information on socio-demographic characteristics, child-related variables, and the prevalence of gastrointestinal, respiratory, and dermatological symptoms.

Table 1: Socio-Demographic Characteristics of Respondents

Variables (Age in years)	Number (n)	Percentage (%)
18-39	183	91.5
40-64	17	8.5
Sex		
Male	11	5.5
Female	189	94.5
Education		
Non-formal education	19	9.5
Primary completed	30	15.0
Secondary and above	151	75.5
Religion		
Hindu	2	1.0
Muslim	198	99.0
Marital status		
Married	195	97.5
Separated	1	0.5
Widow	4	2.0
Occupation		
Employed	16	8.0
Self -Employed	7	3.5
Day Laborer	3	1.5
Home maker	174	87.0
Average number of family members per room (Mean ± SD)		
	-	7.45±2.45

Most respondents (91.5%) were aged between 18 and 39 years, and 94.5% were females. A significant majority (75.5%) had completed at least secondary education. The vast majority were Muslims (99.0%) and married (97.5%). Homemaking was the predominant occupation (87.0%). On average, there were 7.45 family members per room.

Table 2: Wealth Category of the Respondents

Wealth category	Number (n)	Percentage (%)
Low	12	6.0
medium	188	94.0

The majority (94.0%) of respondents fell under the medium wealth category.
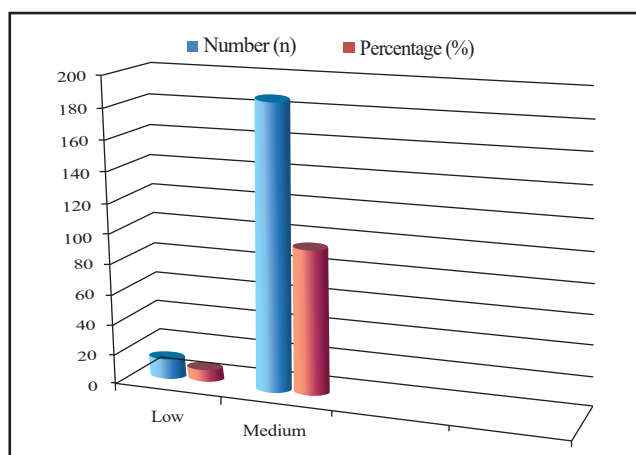

Figure 1 : "Distribution of Participants by Socioeconomic Status: Number and Percentage

Table 3: Water Use–Related Information of the Respondents

Variables	Number (n)	Percentage (%)
Distance from the river		
Less than 100 yards	89	44.5
Between 100 and 200 yards	41	20.5
More than 200 yards	70	35.0
Source of daily water use		
River water	1	0.5
Deep tube well	194	97.0
Supply water	3	1.5
Others	2	1.0
Family members involved in agriculture		
Yes	21	10.5
No	179	89.5

Approximately 44.5% of households were located within 100 yards of the river. The predominant source of household water was deep tube wells (97.0%). Only 10.5% of households had at least one family member involved in agricultural activities.

Table 4: Child-Related Information

Variables	Number (n)	Percentage (%)
Number of children under 5 years		
One	176	88.0
More than one	24	12.0
Age of children (in months)		
0–15	59	29.5
16–30	45	22.5
31–45	45	22.5
46–59	51	25.5
Mean age (months ± SD)	—	28.6 ± 16.6
Sex		
Male	98	49.0
Female	102	51.0

Most households (88.0%) had only one child under five years of age. The average age of children was 28.6 ± 16.6 months, with an almost equal distribution between boys (49.0%) and girls (51.0%).

Table 5: Relationship between Distance from the River and Respiratory Symptoms (Last 30 Days)

Distance from the River	Nasal Discharge	Cough	Shortness of Breath	Wheezing/ Whistling Chest	Throat Pain
Less than 100 yards	73 (36.5%)	58 (29.0%)	20 (10.0%)	28 (14.0%)	5 (2.5%)
100–200 yards	33 (16.5%)	30 (15.0%)	7 (3.5%)	8 (4.0%)	4 (2.0%)
More than 200 yards	48 (24.0%)	44 (22.0%)	13 (6.5%)	17 (8.5%)	7 (3.5%)

Table 5 illustrates the association between the proximity of respondents' homes to the river and the prevalence of respiratory symptoms in the past 30 days. Most respiratory symptoms—such as nasal discharge (36.5%), cough (29.0%), shortness of breath (10.0%), and wheezing (14.0%)—were more common among those living within 100 yards of the river. Throat pain was slightly more prevalent among those living more than 200 yards from the river (3.5%)

Table 6: Relationship between Distance from the River and Gastrointestinal Symptoms (Last 30 Days)

Distance from the River	Diarrhea/ Loose Stool	Vomiting	Abdominal Pain
Less than 100 yards	8 (4.0%)	17 (8.5%)	17 (8.5%)
100–200 yards	6 (3.0%)	8 (4.0%)	6 (3.0%)
More than 200 yards	19 (9.5%)	20 (10.0%)	13 (6.5%)

Table 6 shows that gastrointestinal symptoms such as diarrhea (9.5%) and vomiting (10.0%) were most frequently reported by those residing more than 200 yards from the river. Interestingly, abdominal pain was more common among those living within 100 yards (8.5%).

Table 7: Relationship between Distance from the River and Dermatological Symptoms (Last 30 Days)

Distance from the River	Itching	Rash	Skin Ulceration	Skin color change
Less than 100 yards	9 (4.5%)	10 (5.0%)	4 (2.0%)	2 (1.0%)
100–200 yards	8 (4.0%)	11 (5.5%)	5 (2.5%)	5 (2.5%)
More than 200 yards	18 (9.0%)	20 (10.0%)	17 (8.5%)	11 (5.5%)

Table 7 indicates that dermatological symptoms were more prevalent among individuals living more than 200 yards from the river. Rash (10.0%) was the most common symptom, followed by itching (9.0%), skin ulceration (8.5%), and skin color change (5.5%).

Discussion

This study investigated the relationship between proximity to dye factory effluent-contaminated rivers and the prevalence of respiratory, gastrointestinal, and dermatological symptoms among children under five years of age in two localities of Uttarkhan, Dhaka. The findings reveal important insights into the environmental health risks faced by young children in urban low-income settings impacted by industrial pollution[15]. One of the most notable findings was the significantly higher prevalence of respiratory symptoms—including nasal discharge (36.5%), cough (29.0%), and wheezing (14.0%)—among children living within 100 yards of the river. This trend is consistent with existing literature indicating that close proximity to polluted water bodies, particularly those contaminated by chemical wastes, increases exposure to airborne irritants, molds, and volatile organic compounds, all of which are known triggers of respiratory problems in children[16]. Overcrowding, as seen in the high average number of family members per room (7.45), may further compound this risk by facilitating the spread of respiratory infections, the prevalence of gastrointestinal symptoms—such as diarrhea (9.5%) and vomiting (10.0%)—was higher among children residing more than 200 yards from the river, which contrasts with the expected pattern[17]. This suggests that the cause of gastrointestinal illness may not be directly related to the river's proximity alone. Other factors, such as contaminated food, poor sanitation, and inadequate hand hygiene, may contribute significantly to these illnesses[18]. Despite 97% of households using deep tube wells, the risk of groundwater contamination through surface seepage or improperly sealed tube wells cannot be ruled out[19]. Dermatological symptoms, including rash (10.0%), itching (9.0%), and skin ulceration (8.5%), were also more prevalent among those living more than 200 yards from the river[20]. This counterintuitive finding may reflect alternative exposure routes, such as contaminated bathing water, poor hygiene conditions, or the use of polluted water for domestic chores[21]. It may also point to the uneven spread of

pollutants, where drainage channels or wind patterns carry industrial discharge beyond immediate riverbanks[22]. The socio-demographic profile of the respondents—predominantly young (91.5%, aged 18–39), female (94.5%), and educated (75.5% with secondary or higher education)—suggests that while basic health knowledge may be present, limited economic means and environmental control may hinder their ability to protect children from environmental hazards[23]. The fact that 87% of women were homemakers further highlights their central role in caregiving and household water management, making them essential stakeholders in any future intervention strategies[24]. Another key takeaway is that the vast majority of respondents (94%) fell under the medium wealth category, indicating that financial status alone does not safeguard against environmental health risks[25]. This underlines the importance of structural and environmental determinants—such as waste disposal policies, industrial regulation, and urban planning—over individual or household-level wealth and behavior[26]. While this study sheds light on critical public health issues, certain limitations must be acknowledged[27]. The cross-sectional design captures only short-term prevalence and does not establish causality[28]. Additionally, health symptoms were self-reported, which may introduce recall bias. Environmental samples (air, water, soil) were not analyzed, limiting the ability to link symptoms to specific pollutants[29]. Nevertheless, the consistency of symptom patterns with distance from the river and the clustering of respiratory symptoms near known pollution sources strengthen the study's internal validity[30]. In a nutshell, this study highlights a clear association between residential proximity to polluted rivers and increased respiratory symptoms among children under five. It also reveals complex patterns of gastrointestinal and dermatological illnesses that may be influenced by additional environmental and behavioral factors [31]. These findings call for urgent, multi-sectoral interventions—including environmental clean-up, enforcement of industrial waste management, improved sanitation, and community-level health education. Without such measures, the invisible toll of industrial pollution on child health in urban Dhaka will continue to grow, posing long-term consequences for public health and development.

Conclusion

This study highlights the significant impact of environmental pollution—particularly from dye factory effluents—on the health of children under five living in Uttarkhan, Dhaka. The findings demonstrate a strong association between close residential proximity to polluted rivers and the increased prevalence of respiratory symptoms such as nasal discharge, cough, and wheezing. While gastrointestinal and dermatological symptoms were more common among those living further from the river, this may reflect additional environmental exposures, poor sanitation, or water handling practices beyond river

proximity alone. Despite most households relying on deep tube wells and having moderate socioeconomic status, the burden of illness remains high, especially in overcrowded living conditions. This underscores the complex interplay of environmental, infrastructural, and social determinants in shaping child health outcomes in urban low-income settings. The study emphasizes the urgent need for comprehensive public health interventions, including:

- Strict regulations of industrial waste disposal.

- Improved sanitation and hygiene infrastructure.

- Community awareness and education programs.

- Targeted health services for vulnerable children.

Addressing environmental pollution must become a public health priority in Dhaka and other rapidly urbanizing areas of Bangladesh. Protecting the health of children—particularly those growing up in industrially contaminated zones—is not just a medical concern but a moral and developmental imperative.

Reference

1. Rahaman MA, Kalam A, Al-Mamun M. Unplanned urbanization and health risks of Dhaka City in Bangladesh: uncovering the associations between urban environment and public health. Front Public Health. 2023;11:1269362. doi: 10.3389/fpubh.2023.1269362.

2. Abdalla S, Apramian SS, Cantley LF, et al. Occupation and risk for injuries. In: Mock CN, Nugent R, Kobusingye O, et al., editors. Injury Prevention and Environmental Health. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017. Available from: http://www.ncbi.nlm.nih.gov/books/NBK525209/ (accessed 23 July 2025).

3. Morales F, Montserrat-de la Paz S, Leon MJ, Rivero-Pino F. Effects of malnutrition on the immune system and infection and the role of nutritional strategies regarding improvements in children's health status: a literature review. Nutrients. 2024;16(1):1. doi: 10.3390/nu16010001.

4. Uddin MJ, Jeong Y-K. Urban river pollution in Bangladesh during last 40 years: potential public health and ecological risk, present policy, and future prospects toward smart water management. Heliyon. 2021;7(2):e06107. doi: 10.1016/j.heliyon.2021.e06107.

5. Afrad MSI, Monir MB, Haque ME, et al. Impact of industrial effluent on water, soil and rice production in Bangladesh: a case of Turag River bank. J Environ Health Sci Eng. 2020;18:825–834.

6. Islam M, Islam K, Dalal K, et al. In-house environmental factors and childhood acute respiratory infections in under-five children: a hospital-based matched case-control study in Bangladesh. BMC Pediatr. 2024;24:38. doi: 10.1186/s12887-024-04525-4.

7. Ferguson KT, Cassells RC, MacAllister JW, Evans GW. The physical environment and child development: an international review. Int J Psychol. 2013;48(5):437–468.

8. The Minderoo-Monaco Commission on Plastics and Human Health. [Internet]. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10038118/ (accessed 25 July 2025).

9. Virolainen SJ, VonHandorf A, Viel KCMF, et al. Gene–environment interactions and their impact on human health. Genes Immun. 2023;24(1):1–11. doi: 10.1038/s41435-022-00192-6.

10. Leonardi GS, Zeka A, Ashworth M, et al. A new environmental public health practice to manage current and future global health challenges through education, training, and capacity building. Front Public Health. 2024;12:1373490.

11. Hutton G, Chase C. Water supply, sanitation, and hygiene. In: Mock CN, Nugent R, Kobusingye O, et al., editors. Injury Prevention and Environmental Health. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017. Available from: http://www.ncbi.nlm.nih.gov/books/NBK525207/ (accessed 25 July 2025).

12. Workshop overview – The causes and impacts of neglected tropical and zoonotic diseases. NCBI Bookshelf. Available from: https://www.ncbi.nlm.nih.gov/books/NBK62526/ (accessed 25 July 2025).

13. Abstracts from the 2024 Annual Meeting of the Society of General Internal Medicine. Soc Gen Intern Med. 2024. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11231130/ (accessed 25 July 2025).

14. Lainidi O, Jendeby MK, Montgomery A, et al. An integrative systematic review of employee silence and voice in healthcare: what are we really measuring? Front Psychiatry. 2023;14:1111579. doi: 10.3389/fpsyt.2023.1111579.

15. Children's Environmental Health. National Institute of Environmental Health Sciences. Available from: https://www.niehs.nih.gov/health/topics/population/children (accessed 24 July 2025).

16. Chance GW. Environmental contaminants and children's health: cause for concern, time for action. Paediatr Child Health. 2001;6(10):731–743.

17. Islam M, Sultana ZZ, Iqbal A, et al. Effect of in-house crowding on childhood hospital admissions for acute respiratory infection: a matched case-control study in Bangladesh. Int J Infect Dis. 2021;105:639–645.

18. Kariuki EN, Ng'ang'a ZW, Wanzala P. Food-handling practices and environmental factors associated with food contamination among street food vendors in Nairobi County, Kenya: a cross-sectional study. East Afr Health Res J. 2017;1(1):62–71.

19. Winston JJ, Escamilla V, Perez-Heydrich C, et al. Protective benefits of deep tube wells against childhood diarrhea in Matlab, Bangladesh. Am J Public Health. 2013;103(7):1287–1291. doi: 10.2105/AJPH.2012.300987.

20. Roh YS, Choi J, Sutaria N, et al. Itch: epidemiology, clinical presentation, and diagnostic workup. J Am Acad Dermatol. 2022;86(1):1–14. doi: 10.1016/j.jaad.2021.06.025.

21. Zulkifli SN, Rahim HA, Lau W-J. Detection of contaminants in water supply: a review on state-of-the-art monitoring technologies and their applications. Sens Actuators B Chem. 2018;255:2657–2689. doi: 10.1016/j.snb.2017.10.158.

22. Saad A, Asari F, Affandi S, et al. River pollution: a mini review of causes and effects. J Tourism Hosp Environ Manage. 2022;7:139–151.

23. Baker DP, Leon J, Smith Greenaway EG, et al. The education effect on population health: a reassessment. Popul Dev Rev. 2011;37(2):307–332.doi: 10.1111/j.1728-4457.2011.00412.x.

24. Sharma N, Chakrabarti S, Grover S. Gender differences in caregiving among family-caregivers of people with mental illnesses. World J Psychiatry. 2016;6(1):7–17. doi: 10.5498/wjp.v6.i1.7.

25. National Academies of Sciences, Engineering, and Medicine; Board on Children, Youth, and Families; Committee on Opportunity Gaps in Early Childhood Care and Education. Opportunity gaps in early care and education experienced by children from birth to pre-K. In: Closing the Opportunity Gap for Young Children. National Academies Press (US); 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK596379/ (accessed 24 July 2025).

26. Foellmer J, Liboiron M, Rechenburg A, et al.

Introduction. In: How do the cultural contexts of waste practices affect health and well-being? WHO Regional Office for Europe; 2022. Available from: https://www.ncbi.nlm.nih.gov/books/NBK582040/ (accessed 24 July 2025).

27. Anesi GL, Kerlin MP. The impact of resource limitations on care delivery and outcomes: routine variation, the coronavirus disease 2019 pandemic, and persistent shortage. Curr Opin Crit Care. 2021;27(5):513–519. doi: 10.1097/MCC.0000000000000859.
28. Capili B. Overview: cross-sectional studies. Am J Nurs. 2021;121(6):59–62.

29. Kjellstrom T, Lodh M, McMichael T, et al. Air and water pollution: burden and strategies for control. In: Jamison DT, Breman JG, Measham AR, et al., editors. Disease Control Priorities in Developing Countries. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2006. Available from: http://www.ncbi.nlm.nih.gov/books/NBK11769/ (accessed 24 July 2025).

30. Gu J, Shi Y, Zhu Y, et al. Ambient air pollution and cause-specific risk of hospital admission in China: a nationwide time-series study. PLoS Med. 2020;17(12):e1003188. doi: 10.1371/journal.pmed.1003188.

31. Mahmud MdR, Akter S, Tamanna SK, et al. Impact of gut microbiome on skin health: gut-skin axis observed through the lenses of therapeutics and skin diseases. Gut Microbes. 2024;14:2096995.