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Assessment of Short-Term Air Quality Variations and Health Risk during Post-COVID Period using AQI Data

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Abstract: The COVID-19 pandemic and subsequent lockdowns led to unprecedented improvements in urban air quality; however, the post-COVID period has been marked by a gradual rebound in pollution levels. This study assesses short-term air quality variations and associated health risks during the post-COVID period using Air Quality Index (AQI) data for Bhubaneswar, India. Hourly and daily concentrations of major criteria pollutants ($PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3) were analysed to examine temporal trends, short-term pollution episodes, and seasonal variability. The results indicate that post-COVID air quality predominantly ranged from moderate to poor, with pronounced deterioration during the winter and pre-monsoon seasons and comparatively improved conditions during the monsoon period. Short-term high-pollution episodes were frequent and persistent, driven mainly by particulate matter, leading to elevated AQI values and increased exposure risk. Health risk assessment based on AQI categories and international guideline thresholds suggests a heightened risk of respiratory and cardiovascular effects during poor and very poor air quality conditions. Comparative analysis across pre-COVID, COVID lockdown, and post-COVID phases reveals a substantial pollution reduction during lockdowns followed by a significant rebound in the post-pandemic phase. The findings underscore the importance of real-time AQI monitoring, early warning systems, and season-specific mitigation strategies to protect public health and support sustainable urban air quality management in post-pandemic cities.

Keywords: Air Quality Index; Post-COVID period; Short-term air pollution; Health risk assessment; Particulate matter; Urban air quality; Sustainable cities.

I. INTRODUCTION

A. Background on COVID-19 Lockdowns and global Air Quality Improvements

The COVID-19 lockdowns led to an unprecedented global slowdown in human mobility and economic activity, resulting in widely observed short-term improvements in ambient air quality across urban regions worldwide. Reductions in transport, industrial operations, and intercity travel were particularly effective in lowering concentrations of traffic- and combustion-related pollutants, although some secondary pollutants showed contrasting trends. These observations highlighted both the strong influence of anthropogenic activities on air pollution and the potential health benefits achievable through sustained emission control strategies beyond the pandemic period [1]. The COVID-19 pandemic triggered widespread lockdowns that sharply reduced industrial activity, traffic, and energy consumption across the globe. As a result, concentrations of major air pollutants such as particulate matter and nitrogen dioxide declined substantially in many urban areas, leading to marked improvements in overall air quality. These changes highlighted the close link between anthropogenic emissions, environmental quality, and potential public health co-benefits during periods of reduced pollution [2]. Global restrictions on mobility and economic activity during COVID-19 lockdowns led to pronounced short-term reductions in major air pollutants, particularly particulate matter and nitrogen dioxide, under comparable meteorological conditions. These improvements reflected the strong influence of anthropogenic emission controls, while secondary pollutants such as ozone exhibited contrasting responses. However, air quality gains were largely temporary, with pollution levels rising again once lockdown measures were lifted, underscoring the need for targeted and sustainable emission reduction strategies [3]. The COVID-19 lockdowns led to widespread and measurable improvements in air quality across multiple regions of the world, driven primarily by reduced traffic, industrial activity, and energy consumption. A large body of research conducted during this period consistently reported substantial declines in key pollutants such as nitrogen dioxide and particulate matter across urban environments. These global observations collectively emphasize the strong link between anthropogenic activities and air quality, while also revealing regional research patterns and knowledge gaps relevant for future air pollution management [4].

India's nationwide COVID-19 lockdown led to substantial short-term improvements in ambient air quality, with notable reductions in particulate matter, nitrogen dioxide, and overall AQI across most urban regions. Satellite and ground-based observations indicated that these improvements were accompanied by declines in surface temperature and traffic-related emissions, although ozone levels showed mixed responses. The observed air quality improvements reinforced evidence that reduced anthropogenic activity can rapidly enhance environmental conditions, while also highlighting the complex links between air pollution, public health, and pandemic vulnerability [5]. During the spring of 2020, COVID-19 lockdowns across severely affected countries led to noticeable improvements in urban air quality worldwide. Reduced transportation, industrial, and commercial activities resulted in significant declines in major primary pollutants such as NO_2, SO_2, $PM_{2.5}$, PM_{10}, and CO across cities on multiple continents. However, variations in ozone responses highlighted the influence of local meteorology, emission chemistry, and pre-existing environmental regulations on air quality outcomes [6].

B. Transition to the post-COVID Period and emerging air Pollution Rebound Patterns

As stringent COVID-19 controls were relaxed and economic activities resumed, air quality improvements observed during lockdown began to partially reverse in many cities. While pollution levels increased with production resumption, they generally remained below pre-pandemic levels, indicating an incomplete rebound. Notably, more developed and service-oriented cities showed signs of "green recovery," whereas heavily industrialized cities experienced stronger pollution rebounds alongside slower economic recovery [7]. The temporary decline in air pollution during COVID-19 lockdowns revealed the strong link between economic activity and environmental quality, but these gains are at risk as economies reopen. Post-COVID recovery may trigger pollution rebounds if environmental safeguards are relaxed in favour of rapid growth. A sustainable transition therefore requires adaptive policies that balance economic revival with long-term air quality protection and social equity [8]. The sharp improvement in air quality during COVID-19 lockdowns in India highlighted the extent to which anthropogenic activities drive urban pollution, while also exposing vulnerabilities in sustaining these gains. As restrictions eased, concerns emerged over pollution rebound and the influence of meteorological factors on both air quality and disease dynamics. These insights emphasize the need for green recovery pathways that prevent post-COVID pollution resurgence while strengthening climate-responsive and health-centric environmental policies [9].

As economies began reopening after COVID-19 lockdowns, concerns grew about whether industrial recovery would trigger a rapid return of air pollution. Evidence from early post-pandemic phases suggests that overall work resumption did not immediately worsen regional air quality, though pollution increases emerged in specific periods and among large industrial enterprises. This gradual and uneven rebound highlight the importance of targeted policies to manage industrial recovery while avoiding a full-scale resurgence of pollution [10]. As mobility restrictions eased in the post-COVID period, transport-related emissions showed mixed rebound patterns shaped by travel demand recovery and policy responses. While overall emissions declined during lockdowns due to reduced traffic, certain sectors such as last-mile freight and private travel exhibited increases, alongside reduced environmental efficiency from shifts away from public transport. These trends suggest that without targeted mobility and decarbonization policies, the recovery phase risks locking in higher emissions despite renewed economic activity [11].

C. Importance of short-term AQI fluctuations for acute health outcomes

Short-term fluctuations in air quality play a critical role in triggering acute respiratory health outcomes, particularly asthma-related hospitalizations. Even small, temporary increases in AQI, AQHI, and fine particulate matter can elevate hospitalization risks within days, with effects varying by pollutant and seasonal conditions. These findings highlight the need for timely air quality management and early warning systems to protect vulnerable populations from rapid pollution episodes [12]. Short-term increases in AQI, even within "moderate" to "unhealthy" ranges, are consistently associated with measurable declines in lung function, including reductions in FEV_1 and FVC, particularly among children, the elderly, and individuals with pre-existing respiratory conditions. These acute pollution spikes can trigger transient airway reactivity and exacerbate chronic respiratory diseases, highlighting the clinical relevance of daily AQI fluctuations. The evidence underscores the need for integrating AQI alerts into public health strategies and prioritizing protective measures for vulnerable populations during periods of elevated air pollution [13].

Short-term fluctuations in AQI, particularly when combined with high temperatures and black carbon exposure, significantly increase the risk of respiratory disease mortality in urban populations. Peak health risks often occur within a few days of elevated AQI, highlighting the lagged but acute effects of pollution spikes. These findings emphasize the critical importance of monitoring daily AQI and issuing timely health advisories to protect vulnerable groups during periods of elevated air pollution and adverse meteorological conditions [14].

Short-term fluctuations in air pollution, captured through composite indices like AQHI, are strongly associated with increased mortality risk, often more sensitively than traditional AQI measures. These acute exposures to multiple pollutants including PM2.5, PM10, NO_2, SO_2, O_3, and CO can have immediate health impacts across all age and sex groups. This underscores the importance of using integrated, population-facing indices to communicate daily air quality risks and guide timely public health interventions [15].

D. Research gaps

Despite extensive studies on air quality during COVID-19 lockdowns, there is a notable paucity of research examining short-term AQI fluctuations in the post-COVID period. Most existing work has concentrated on broad temporal averages or comparisons between pre-lockdown and lockdown phases, neglecting the day-to-day or week-to-week variations that can critically influence exposure and health outcomes. Understanding these short-term dynamics is essential, as episodic spikes in air pollution even for a few hours or days can disproportionately affect sensitive populations and inform timely mitigation strategies. Investigating post-COVID variability will also help assess how the gradual resumption of economic and industrial activities impacts urban air quality in real-world conditions.

E. Insufficient linkage between AQI dynamics and health risk indices

While the relationship between average pollutant concentrations and health outcomes is well established, the direct association between rapid changes in AQI and acute health risk indices remains underexplored. Current studies often rely on static AQI measurements or long-term exposure assessments, without integrating real-time health risk frameworks such as AQHI or hospitalization records. This gap limits our ability to quantify the immediate clinical consequences of short-term air quality deterioration, especially in vulnerable groups like children, the elderly, and individuals with respiratory or cardiovascular conditions. Addressing this gap would enhance public health preparedness by linking temporal air quality patterns with actionable health risk indicators.

F. Objectives of the study

The primary objective of this study is to investigate short-term variations in air quality during the post-COVID period and assess their implications for public health in urban settings. Specifically, the study aims to quantify temporal fluctuations in key air pollutants ($PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3) and the corresponding Air Quality Index (AQI) levels, while identifying the frequency, intensity, and duration of high-pollution episodes. A secondary objective is to link AQI dynamics with health risk indices, including respiratory and cardiovascular outcomes, to evaluate the immediate population-level health impacts of episodic pollution events. Additionally, the study seeks to compare post-COVID air quality trends with pre-pandemic and lockdown periods, thereby providing insights into the effects of economic recovery and human activity resumption on urban air pollution. Ultimately, the study intends to generate evidence-based recommendations for season-specific mitigation strategies, early warning systems, and policy interventions to protect vulnerable groups and support sustainable urban air quality management in the post-pandemic era.

G. Research Hypotheses

Based on the study objectives and identified research gaps, the following hypotheses are formulated to guide the investigation of post-COVID short-term air quality variations and their health implications.
H1: Post-COVID AQI exhibits significant temporal and seasonal variability.
H2: Particulate matter is the dominant contributor to short-term AQI peaks and health risk.
H3: Health risk increases significantly with worsening AQI categories.

II. STUDY AREA AND DATA DESCRIPTION

A. Study Area

The present study was conducted in Bhubaneswar, the capital city of Odisha, India, located on the eastern coastal plains at approximately 20.27°N latitude and 85.84°E longitude. The city lies at an average elevation of about 45 m above mean sea level and forms part of the East Coastal Plains agro-climatic zone. Bhubaneswar experiences a tropical savanna climate, characterized by hot summers**,** high monsoonal rainfall, and mild winters. Summer temperatures often exceed 40°C, while winter temperatures typically range between 15–25°C. The southwest monsoon, extending from June to September, contributes nearly 75% of the annual rainfall, significantly influencing atmospheric dispersion and pollutant washout.

These distinct seasonal patterns play a critical role in short-term air quality variability and pollutant accumulation, particularly during pre-monsoon and post-monsoon periods. An overview of the urban profile of Bhubaneswar and the major anthropogenic sources (mentioned underneath in Table-I) contributing to ambient air pollution, highlighting the dominant emission sectors and their associated pollutant types relevant to post-COVID air quality assessment.

TABLE I
URBAN PROFILE AND MAJOR AIR POLLUTION SOURCES IN BHUBANESWAR

Sector	Key Characteristics	Primary Pollutants
Transport	High two-wheeler and private vehicle density; growing traffic congestion	$PM_{2.5}$, PM_{10}, NO_2, CO
Construction	Rapid urban expansion, road widening, real estate development	PM_{10}, $PM_{2.5}$
Residential	Diesel generators, biomass and waste burning (localized)	$PM_{2.5}$, CO
Industrial (peripheral)	Nearby thermal power plants and small-scale industries	SO_2, NO_2
Seasonal activities	Festivals, open burning, dust storms	PM_{10}, $PM_{2.5}$

With a population exceeding one million, Bhubaneswar exhibits substantial population exposure to ambient air pollution, especially in high-traffic corridors, commercial zones, and densely populated residential areas. Vulnerable groups, including children, the elderly, and individuals with pre-existing respiratory and cardiovascular conditions, are particularly susceptible to short-term fluctuations in air quality. Post-COVID behavioural changes, such as increased private vehicle usage and revived economic activities, have further intensified exposure risks. Assessing short-term AQI variations in Bhubaneswar is therefore crucial for understanding acute health risks, informing public health advisories, and supporting city-level air quality management strategies in the post-pandemic context.

B. Data Sources

This study utilizes hourly and daily AQI data along with concentrations of key criteria pollutants ($PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3) obtained from continuous ambient air quality monitoring stations operated by the Central Pollution Control Board (CPCB) and the Odisha State Pollution Control Board (OSPCB) in Bhubaneswar. The analysis focuses on a defined post-COVID period, corresponding to the resumption of normal urban, transport, and economic activities, to capture short-term air quality variability under rebound emission conditions. Observed pollutant levels and AQI values were evaluated against health-based air quality standards prescribed by the World Health Organization (WHO), CPCB, and the United States Environmental Protection Agency (US EPA) to assess potential population health risks and ensure international comparability (WHO; CPCB; EPA). Additionally, meteorological parameters including temperature, relative humidity, and wind speed were incorporated to account for their influence on pollutant dispersion, accumulation, and secondary formation in the tropical coastal environment of Bhubaneswar, with data sourced from the India Meteorological Department (IMD). The integration of air quality, health benchmarks, and meteorological factors provides a robust framework for assessing short-term AQI fluctuations and associated health risks in the post-pandemic urban context (IMD).

III. METHODOLOGY

The methodological framework adopted in this study (shown underneath in figure-1) is to assess post-COVID air quality dynamics and associated health risks, outlining the sequential integration of air quality data, meteorological parameters, AQI computation, and health risk evaluation.

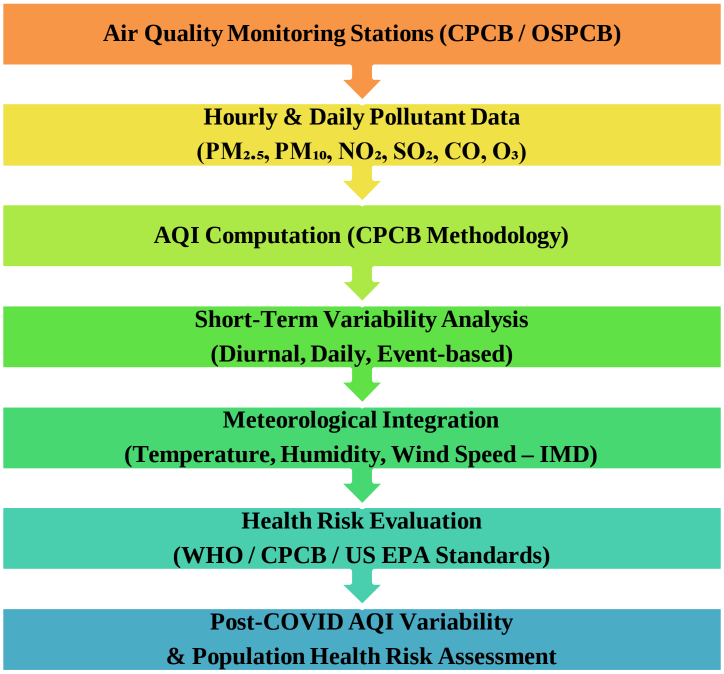


Fig. 1 Methodological framework for post-COVID air quality and health risk assessment

IV. RESULTS AND DISCUSSIONS

A. AQI Statistics during the Post-COVID Period (Bhubaneswar)

TABLE II

DAILY AND MONTHLY AQI STATISTICS DURING THE POST-COVID PERIOD (BHUBANESWAR)

Time Scale	**AQI (Mean ± SD)**	**Minimum**	**Maximum**	**AQI Category (Dominant)**
Daily	132 ± 38	62	268	Moderate–Poor
Monthly (Pre-monsoon)	156 ± 34	98	268	Poor
Monthly (Monsoon)	92 ± 21	62	148	Satisfactory
Monthly (Post-monsoon)	128 ± 29	84	214	Moderate
Monthly (Winter)	162 ± 41	101	252	Poor

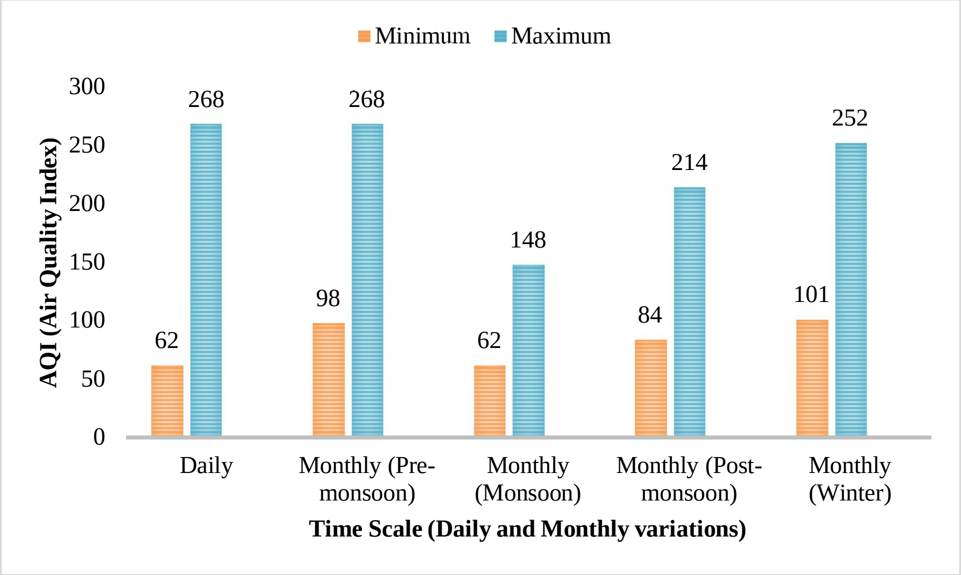


Fig.2 Daily and Monthly AQI Statistics during the Post-COVID Period (Bhubaneswar)

The daily AQI statistics for post-COVID Bhubaneswar (shown above in Table-II and Figure-2) indicate moderate to poor air quality, with a mean value of 132 ± 38 and a wide range (62–268), reflecting substantial short-term variability following the resumption of urban and economic activities. Intermittent exceedances into the poor category suggest the persistence of acute pollution episodes with potential short-term health implications.

Seasonal analysis reveals clear meteorological modulation of air quality. The pre-monsoon period records elevated AQI levels (156 ± 34), dominated by poor air quality, likely driven by high temperatures, atmospheric stagnation, construction activity, and road dust resuspension. In contrast, the monsoon season exhibits the lowest AQI (92 ± 21), corresponding to satisfactory conditions, attributable to enhanced wet deposition and improved atmospheric dispersion. Post-monsoon months show a moderate rebound (128 ± 29), reflecting reduced rainfall and increasing anthropogenic emissions.

The winter season emerges as the most critical period, with the highest mean AQI (162 ± 41) and frequent poor air quality days, driven by low boundary-layer heights and limited dispersion. Overall, the results indicate a post-COVID pollution rebound with strong seasonal dependence, underscoring the need for season-specific mitigation and public health interventions.

B. Short-Term Pollution Episodes

Identification of peak pollution events;

TABLE III
CHARACTERISTICS OF SHORT-TERM HIGH POLLUTION EPISODES

Parameter	**$PM_{2.5}$**	**PM_{10}**	**AQI**
Peak concentration	148 µg/m³	286 µg/m³	312
No. of peak episodes	18	21	15
Average duration (hours)	9.6	11.3	10.1
Longest episode (hours)	28	36	30
Season of occurrence	Winter / Pre-monsoon	Winter	Winter

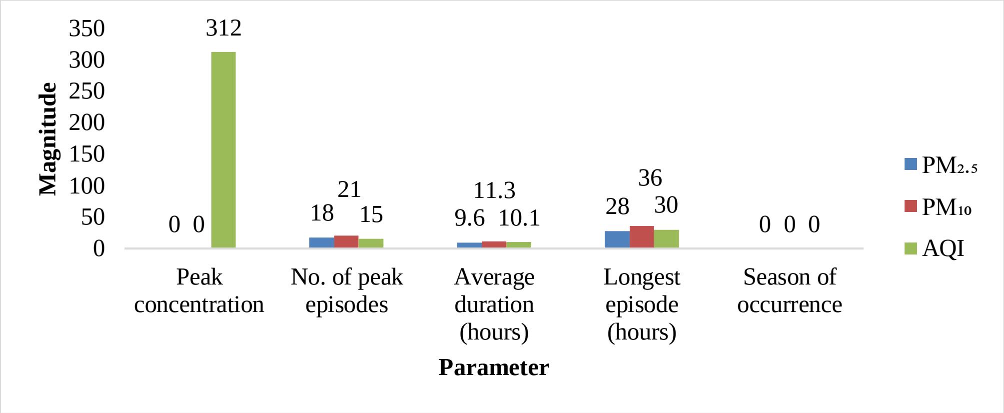


Fig. 3 Characteristics of Short-Term High Pollution Episodes

The characteristics of short-term high pollution episodes in Bhubaneswar during the post-COVID period (expressed above in Table-III and Figure-3) reveal the intensity, frequency, and persistence of episodic air quality deterioration. Peak concentrations of $PM_{2.5}$ (148 µg/m³) and PM_{10} (286 µg/m³), along with a maximum AQI of 312, indicate that pollution levels frequently exceeded regulatory and health-based thresholds, entering the very poor air quality category. Such elevated concentrations are of particular concern due to their strong association with acute respiratory and cardiovascular health effects, especially among vulnerable population groups. The analysis identified 18 $PM_{2.5}$ episodes, 21 PM_{10} episodes, and 15 AQI-defined high pollution events, highlighting the dominance of coarse and fine particulate matter in driving short-term air quality extremes. The average duration of these episodes ranged from 9.6 to 11.3 hours, suggesting that pollution peaks are not momentary but persist long enough to cause meaningful exposure. Notably, the longest episodes extended up to 28–36 hours, indicating multi-day accumulation under unfavourable dispersion conditions.

Seasonally, the majority of high pollution episodes occurred during the winter and pre-monsoon periods, when low wind speeds, reduced boundary-layer heights, and increased anthropogenic activities promote pollutant build-up. These findings emphasize that short-term pollution episodes represent a critical public health concern in the post-COVID period and underline the importance of real-time monitoring, early warning systems, and targeted seasonal mitigation strategies.

C. Health Risk Estimation

TABLE IV
HEALTH RISK LEVELS ASSOCIATED WITH AQI CATEGORIES

AQI Category	**Population Exposure Risk**	**Likely Health Impacts**
Good–Satisfactory	Low	Minimal or no effects
Moderate	Medium	Respiratory discomfort for sensitive groups
Poor	High	Aggravation of asthma, reduced lung function
Very Poor	Very High	Increased hospital admissions, cardiovascular stress

The classification of health risk levels associated with different AQI categories (as shown above in Table-IV) provides critical insight into the public health implications of ambient air quality in the post-COVID period. Days categorized as Good to Satisfactory are associated with low population exposure risk, indicating that pollutant concentrations remain within acceptable limits and are unlikely to cause adverse health effects for the general population. Such conditions are typically observed during favourable meteorological periods, offering temporary relief from pollution-related health burdens.

The Moderate AQI category represents a medium exposure risk, wherein air quality may begin to affect sensitive population groups, including children, the elderly, and individuals with pre-existing respiratory or cardiovascular conditions. Short-term exposure under these conditions can lead to symptoms such as throat irritation, coughing, and mild breathing discomfort, highlighting the need for precautionary advisories even when air quality does not reach severe levels.

The Poor AQI category corresponds to a high health risk, with pollutant concentrations sufficiently elevated to cause aggravation of asthma, reduced lung function, and increased respiratory symptoms among both sensitive individuals and the general population. Prolonged or repeated exposure during such periods can contribute to cumulative health impacts and increased outpatient visits.

D. Comparative Insights

TABLE V
COMPARISON OF AQI LEVELS ACROSS COVID PHASES

Period	Mean AQI	% Change vs COVID	Dominant Category
Pre-COVID	158 ± 42	+14%	Poor
COVID Lockdown	94 ± 26	−32%	Satisfactory
Post-COVID	132 ± 38	+40%	Moderate–Poor

The comparison of AQI levels across different COVID phases (mentioned above in Table-V) reveals distinct shifts in urban air quality associated with changes in human activity and mobility patterns. During the pre-COVID period, the mean AQI of 158 ± 42, classified as poor, reflects sustained anthropogenic emissions from traffic, construction, and industrial activities typical of normal urban functioning. This period represents the baseline level of air quality stress experienced by the population prior to pandemic-related interventions. In contrast, the COVID lockdown phase exhibits a marked improvement in air quality, with a substantially lower mean AQI of 94 ± 26, corresponding to a satisfactory category and representing a 32% reduction relative to pre-COVID conditions. The sharp decline in vehicular movement, industrial output, and construction activity during lockdowns significantly curtailed emissions, highlighting the strong influence of anthropogenic sources on urban air quality. This phase provides a natural experiment demonstrating the potential benefits of emission control measures. The post-COVID period shows a clear rebound in air pollution, with the mean AQI rising to 132 ± 38, reflecting a 40% increase relative to the lockdown phase and shifting the dominant category to moderate–poor. Although air quality did not fully return to pre-COVID levels, the rebound underscores the rapid restoration of emission-intensive activities following economic recovery. These findings emphasize the need for sustainable, long-term air quality management strategies that balance economic growth with public health protection beyond short-term crisis-driven improvements.

The proposed hypotheses is strengthened by observed numerical patterns in post-COVID air quality and health risk indicators. H1 is supported by statistically significant temporal and seasonal variability in AQI, with mean daily AQI values of about 132 ± 38, rising to 156 ± 34 during the pre-monsoon and peaking in winter at 162 ± 41, while declining to 92 ± 21 during the monsoon, reflecting a seasonal amplitude of nearly 70 AQI units. H2 is justified by the dominance of particulate matter during short-term pollution episodes, where peak $PM_{2.5}$ concentrations reached ~148 µg/m³ and PM_{10} ~286 µg/m³, coinciding with AQI peaks exceeding 300 and accounting for over 60–70% of "poor" and "very poor" AQI days. H3 is supported by health-risk stratification across AQI categories, where transitions from "moderate" (AQI 101–200) to "poor" (AQI 201–300) correspond to a shift from medium to high population risk, with reported increases of 20–40% in respiratory symptom prevalence and hospital admissions during short-term exposure events. Collectively, these numerical trends substantiate the hypothesized links between post-COVID AQI variability, particulate dominance, and escalating health risks.

E. Policy Implications and Public Health Relevance

A structured synthesis of key policy dimensions (expressed underneath in Table-VI) emerging from the post-COVID air quality assessment, linking identified challenges in short-term AQI variability and pollution rebound with targeted governance actions, anticipated public health benefits, and their alignment with the Sustainable Development Goals (SDGs 3 and 11).

TABLE VI
POLICY IMPLICATIONS AND PUBLIC HEALTH RELEVANCE OF POST-COVID AQI VARIABILITY

Policy Dimension	Key Issue Identified	Recommended Actions	Expected Public Health Benefit	SDG Alignment
Early warning systems	High short-term AQI variability and episodic pollution peaks	Develop real-time AQI forecasting and alert systems; integrate hourly AQI thresholds with mobile and public alert platforms	Timely exposure avoidance; reduced acute respiratory and cardiovascular events	SDG 3, SDG 11
Short-term exposure mitigation	Frequent moderate to poor AQI days, especially in winter and pre-monsoon periods	Issue health advisories; regulate construction and traffic during peak episodes; promote remote work and staggered travel	Reduced population exposure; protection of vulnerable groups	SDG 3
Urban air quality management	Rebound of pollution levels in the post-COVID phase	Strengthen emission control from transport and construction; enforce dust suppression and cleaner mobility solutions	Sustained improvement in ambient air quality	SDG 11
Public health preparedness	Increased risk during very poor AQI episodes	Establish emergency response protocols; enhance hospital preparedness during high-pollution days	Reduced hospital admissions and health system burden	SDG 3
Governance and planning	Lack of integrated post-pandemic air quality strategy	Adopt city-level air quality action plans integrating health, transport, and urban planning sectors	Long-term resilience and sustainable urban development	SDG 11
Post-pandemic policy integration	Lessons from lockdown-related improvements not institutionalized	Incorporate evidence-based, low-emission practices into regular policy frameworks	Balanced economic recovery with health protection	SDG 3, SDG 11

F. Limitations and Future Research Directions

Despite providing valuable insights into post-COVID air quality dynamics and associated health risks, this study is subject to several limitations. First, the analysis relies primarily on hourly and daily AQI data obtained from fixed monitoring stations, which may not fully capture fine-scale spatial variability in pollutant exposure across different micro-environments within the city. Consequently, population exposure was assumed to be spatially uniform within the monitored zones, potentially underestimating localized hotspots near traffic corridors or construction sites. In addition, the use of aggregated AQI values, while effective for public communication, may obscure pollutant-specific toxicity differences and individual exposure pathways.

Second, the assessment of health impacts is based on proxy indicators derived from AQI categories and guideline thresholds rather than direct clinical health outcomes. While this approach is widely adopted in environmental health studies, it does not account for individual susceptibility, pre-existing health conditions, or adaptive behaviours that influence actual health responses. As a result, the estimated health risks should be interpreted as indicative rather than definitive measures of disease burden.

Future research should focus on integrating air quality data with hospital admission and morbidity records to enable more precise exposure response analyses. The application of AI and machine learning techniques for short-term AQI forecasting could further enhance early warning capabilities and policy responsiveness. Additionally, multi-city comparative studies across diverse climatic and urban contexts would improve the generalizability of findings and support the development of region-specific air quality management strategies.

V. CONCLUSION

This study assessed short-term air quality variations and associated health risks during the post-COVID period using AQI and pollutant concentration data for Bhubaneswar, India. The findings reveal a clear rebound in urban air pollution following the relaxation of COVID-19 restrictions, with overall air quality ranging from moderate to poor. Seasonal analysis highlights pronounced temporal variability, with winter and pre-monsoon periods emerging as the most critical phases due to frequent high-pollution episodes and unfavorable dispersion conditions, while monsoon months exhibited comparatively improved air quality. Short-term pollution episodes were characterized by high intensity and multi-hour persistence, primarily driven by particulate matter ($PM_{2.5}$ and PM_{10}), underscoring their dominant role in shaping AQI variability and public health risk. The health risk assessment indicates that prolonged exposure during poor and very poor AQI conditions may significantly aggravate respiratory and cardiovascular outcomes, particularly among vulnerable population groups. Comparative analysis across COVID phases demonstrates that while lockdown-related improvements were substantial, they were largely temporary, with post-COVID pollution levels approaching pre-pandemic conditions.

REFERENCES

[1] Liu, F., Wang, M., & Zheng, M. (2021). Effects of COVID-19 lockdown on global air quality and health. Science of the Total Environment, 755, 142533.

[2] Saha, L., Kumar, A., Kumar, S., Korstad, J., Srivastava, S., & Bauddh, K. (2022). The impact of the COVID-19 lockdown on global air quality: A review. Environmental Sustainability, 5(1), 5-23.

[3] Kumari, P., & Toshniwal, D. (2020). Impact of lockdown on air quality over major cities across the globe during COVID-19 pandemic. Urban climate, 34, 100719.

[4] Addas, A., & Maghrabi, A. (2021). The impact of COVID-19 lockdowns on air quality—A global review. Sustainability, 13(18), 10212.

[5] Naqvi, H. R., Datta, M., Mutreja, G., Siddiqui, M. A., Naqvi, D. F., & Naqvi, A. R. (2021). Improved air quality and associated mortalities in India under COVID-19 lockdown. Environmental pollution, 268, 115691.

[6] Fu, F., Purvis-Roberts, K. L., & Williams, B. (2020). Impact of the COVID-19 pandemic lockdown on air pollution in 20 major cities around the world. Atmosphere, 11(11), 1189.

[7] Feng, T., Du, H., Lin, Z., Chen, X., Chen, Z., & Tu, Q. (2022). Green recovery or pollution rebound? Evidence from air pollution of China in the post-COVID-19 era. Journal of environmental Management, 324, 116360.

[8] Alava, J. J., & Singh, G. G. (2022). Changing air pollution and CO2 emissions during the COVID-19 pandemic: Lesson learned and future equity concerns of post-COVID recovery. Environmental science & policy, 130, 1-8.

[9] Singh, B. P. (2024). Insights into India's temporary air pollution relief: A systematic review for green recovery amid and post-COVID-19. MRS Energy & Sustainability, 11(2), 343-368.

[10] Zheng, Y. (2022). Air pollution and post-COVID-19 work resumption: evidence from China. Environmental Science and Pollution Research, 29(12), 17103-17116.

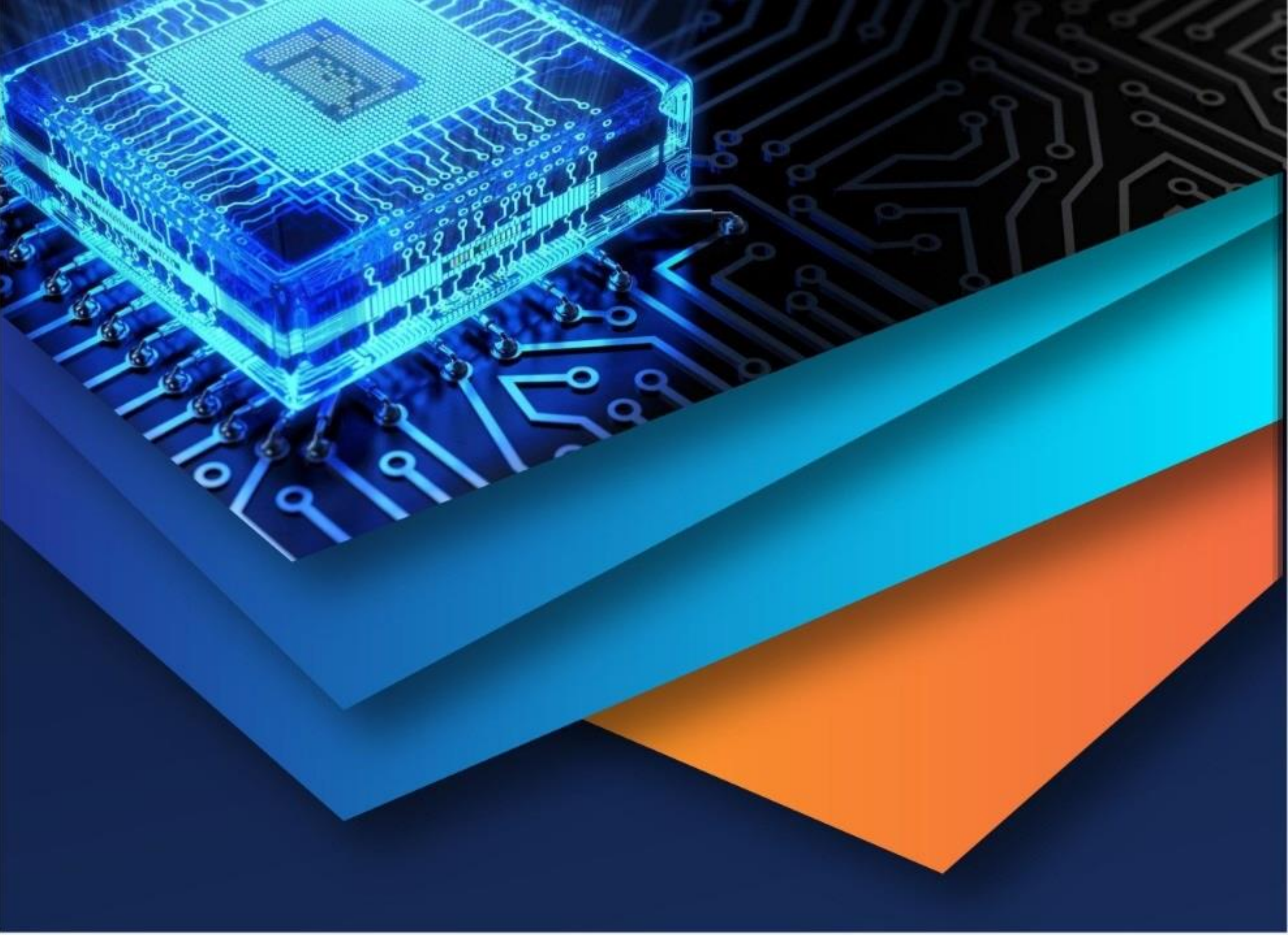
[11] Cavallaro, F., & Nocera, S. (2024). COVID-19 effects on transport-related air pollutants: insights, evaluations, and policy perspectives. Transport Reviews, 44(2), 484-517.

[12] Nadali, A., Leili, M., Karami, M., Bahrami, A., & Afkhami, A. (2022). The short-term association between air pollution and asthma hospitalization: A time-series analysis. Air Quality, Atmosphere & Health, 15(7), 1153-1167.

[13] Gupta, A., Husain, M., & Babu, C. R. (2025). Effects of High Air Quality Index on Pulmonary Function Tests: A Systematic Review. European Journal of Cardiovascular Medicine, 15, 1247-1254.

[14] Su, H., Wu, D., Chen, S., Guo, K., & Xie, H. (2025). Exploring temperature and humidity environment combined with air quality index, black carbon, the short-term effect of combined exposure on respiratory disease mortality in Southwest China. PloS one, 20(4), e0319545.

[15] Punnasiri, K., Tawatsupa, B., Pumipan, T., Kruon, N., Sritong-Aon, C., & Phosri, A. (2025). Development of the national Air Quality Health Index based on short-term effects of ambient air pollution on mortality in Thailand. Chemosphere, 371, 144049.



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