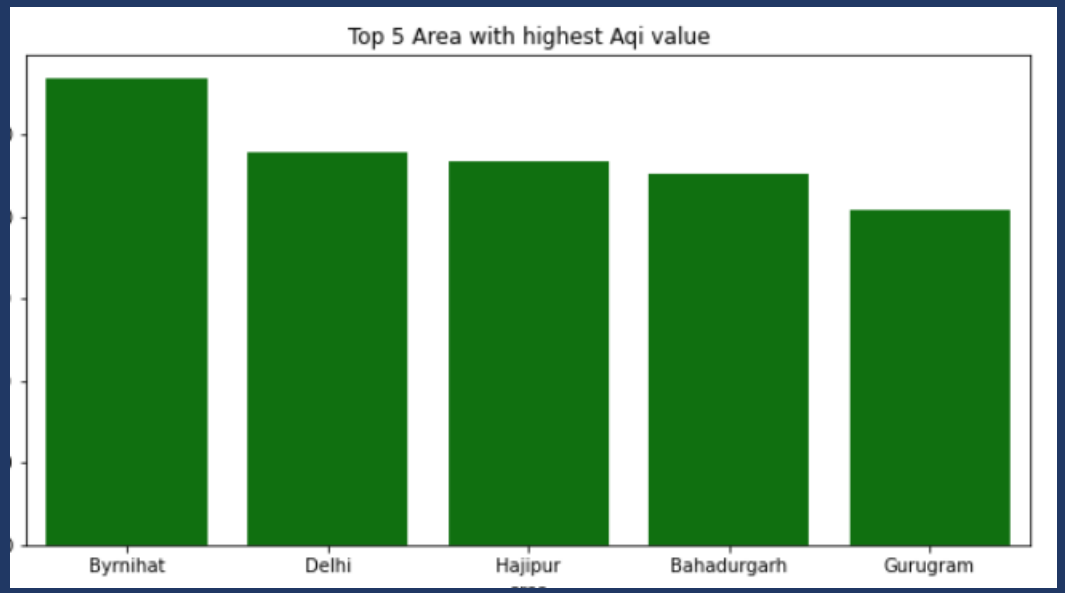
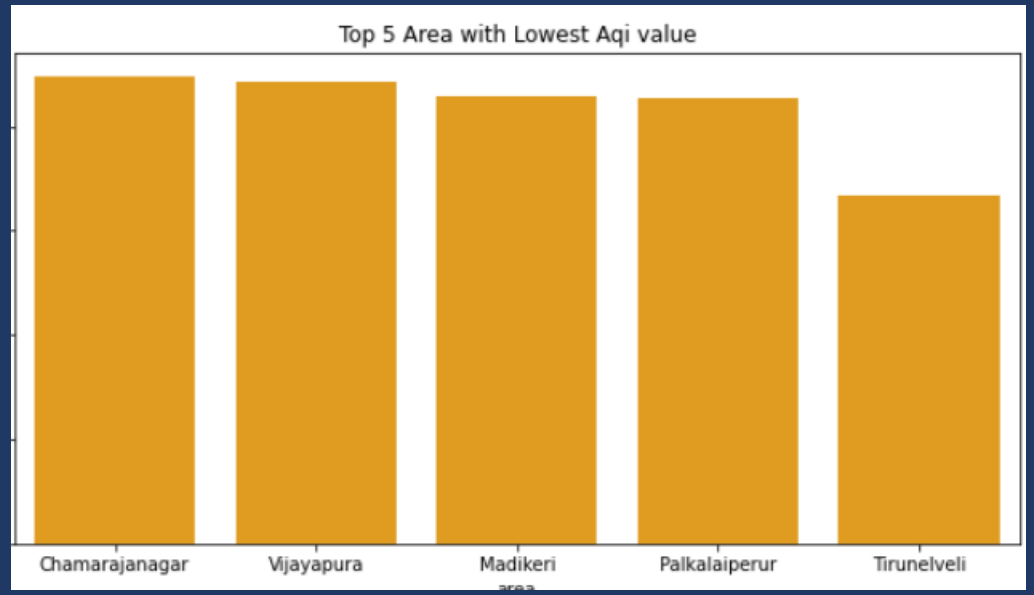
Primary Analysis

1. List the top 5 and bottom 5 areas with highest average AQI. (Consider areas which contains data from last 6 months: December 2024 to May 2025)

Top 5 Area's



Bottom 5 area's



2. List out top 2 and bottom 2 prominent pollutants for each state of southern India. (Consider data post covid: 2022 onwards)

Top 5 states

state	prominent_pollutants	count
Andhra Pradesh	PM10	2622
Andhra Pradesh	PM2.5	1525
Karnataka	PM10	10787
Karnataka	CO	2112
Kerala	PM10	2252
Kerala	PM2.5	720
Tamil Nadu	PM10	5603
Tamil Nadu	PM2.5	2032
Telangana	PM10	308
Telangana	PM2.5,PM10	259

Bottom 5 states

state	prominent_pollutants	count
Andhra Pradesh	PM10,NO2,PM2.5,O3	1
Andhra Pradesh	PM2.5,CO,O3	1
Karnataka	PM2.5,NO2	1
Karnataka	SO2,O3	1
Kerala	NO2	3
Kerala	CO,NO2	1
Tamil Nadu	PM10,NH3,CO	1
Tamil Nadu	PM10,NO2,PM2.5,O3	1
Telangana	PM10,O3,CO	1
Telangana	PM2.5,NO2	1

PM_{10} and $PM_{2.5}$ – The Most Prominent Pollutants

PM_{10} and $PM_{2.5}$ dominate AQI readings in most regions due to their **high prevalence** and **serious health impacts**.

Insight

- PM_{10} particles are tiny airborne particles with diameters of 10 micrometers or less, commonly generated from dust, pollen, construction activities, and road dust, and they can irritate the respiratory system.

- $PM_{2.5}$ particles are even finer, measuring 2.5 micrometers or less, mainly produced by vehicle emissions, industrial combustion, biomass burning, and chemical reactions in the atmosphere, posing higher health risks.

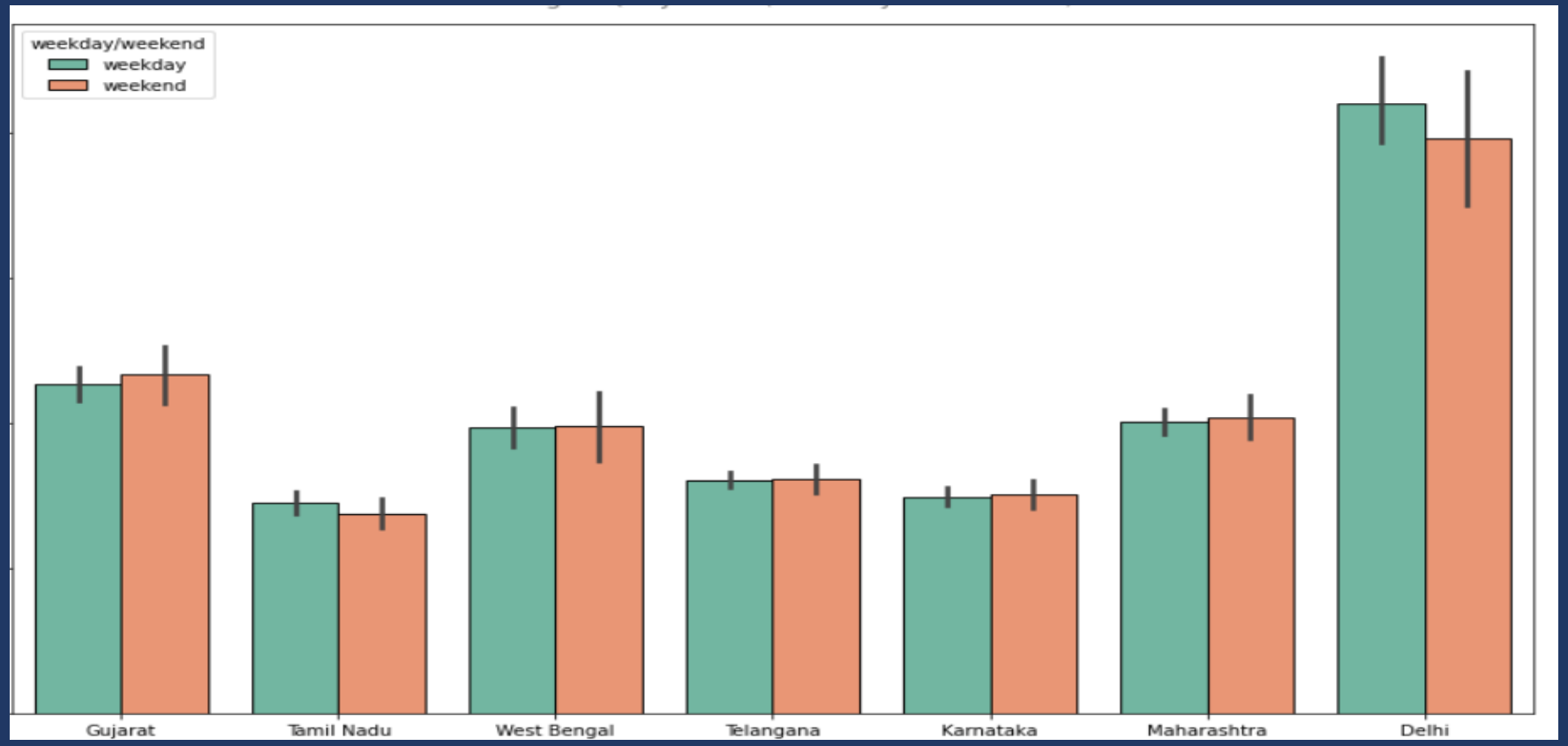
- $PM_{2.5}$ is especially dangerous because its small size allows it to penetrate deep into the lungs and enter the bloodstream, leading to respiratory diseases, heart problems, and other chronic health issues.

- Both PM_{10} and $PM_{2.5}$ reduce visibility, contributing to haze and smog, and harm ecosystems by depositing toxic substances on soil, water, and plants, affecting biodiversity.

- Regulatory agencies worldwide monitor and limit PM_{10} and $PM_{2.5}$ levels, enforcing air quality standards to minimize exposure and protect public health and the environment.

3.Does AQI improve on weekends vs weekdays in Indian metro cities (Delhi, Mumbai, Chennai, Kolkata, Bengaluru, Hyderabad, Ahmedabad, Pune)? (Consider data from last 1 year)

WEEKEND VS WEEKDAY



Insight

No Weekend Break

Most states experience consistently poor air quality every day— weekdays and weekends show little difference.

Delhi's Extreme Pollution

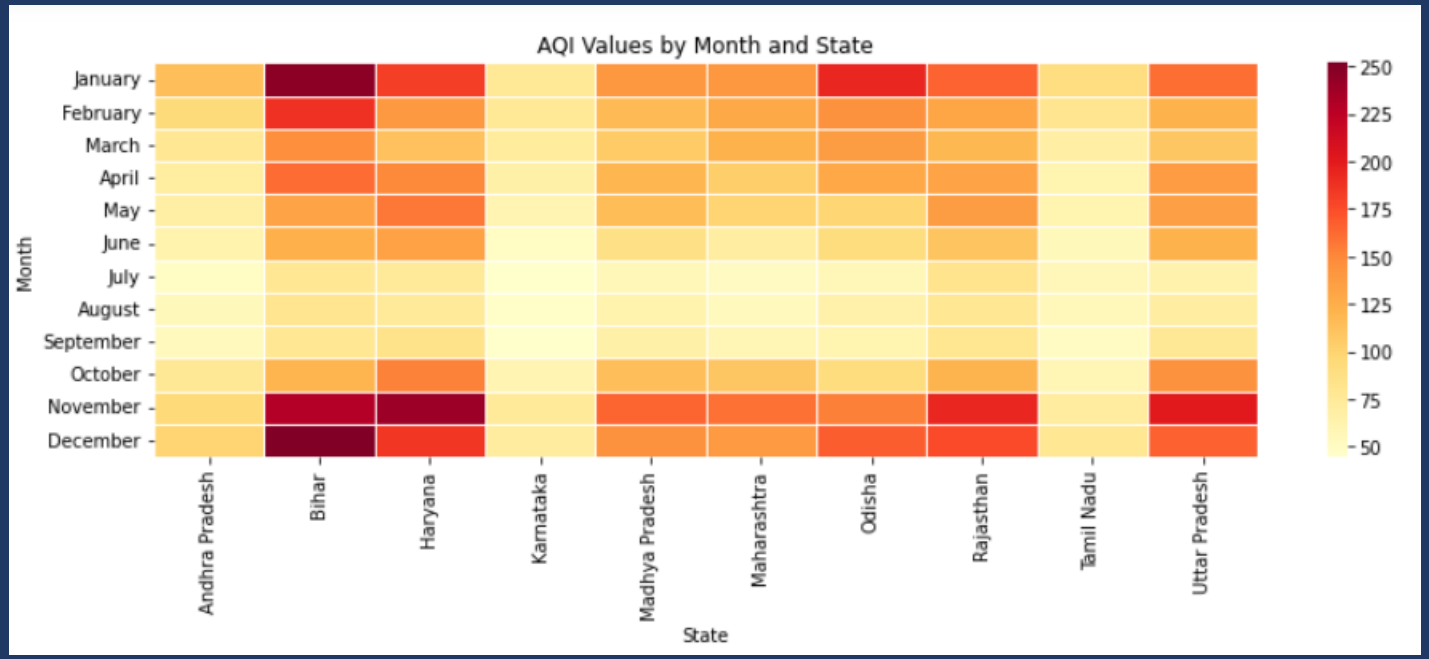
Delhi's Air Quality Index (AQI) is much higher than other states, indicating severe, persistent pollution.

Stubble Burning: Farmers in neighboring states like Punjab and Haryana burn crop residue, and the smoke travels to Delhi.

Year-Round Problem

Pollution isn't only from weekday traffic. Continuous sources like construction, residential burning, and industries contribute daily.

4. Which months consistently show the worst air quality across Indian states — (Consider top 10 states with high distinct areas)



1. **Seasonal Breakouts**

•Winter (Nov–Jan) is the worst AQI period across almost all states.

- **November and December** show extreme spikes — e.g.,
  - **Delhi**: 251.8 (Dec), 229.6 (Nov)
  - **Uttar Pradesh**: 200.6 (Nov)
  - **Rajasthan**: 193.2 (Nov)

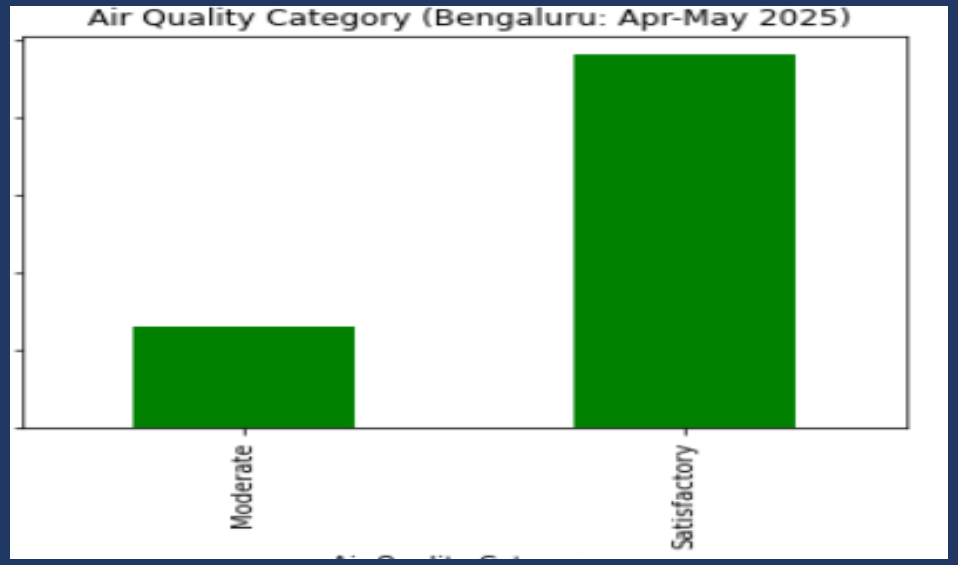
  Likely due to **stubble burning, low wind speeds, and winter inversion trapping pollutants**.

•Summer (Apr–Jun) has moderate AQI levels — except in some industrial states like Rajasthan where April and May remain high.

•Monsoon (Jul–Sep) is the cleanest period — rainfall helps wash pollutants out of the air.

- Example: July AQI ranges from 44.9 (Delhi) to 82.0 (Rajasthan), all much lower than winter peaks.

5.For the city of Bengaluru, how many days fell under each air quality category (e.g., Good, Moderate, Poor, etc.) between March and May 2025?



Bengaluru experienced satisfactory air quality on 48% of days 🌤 and moderate pollution on 13% of days ⚠, indicating mostly good air but occasional mild health risks for sensitive groups 🫁.

6.List the top two most reported disease illnesses in each state over the past three years, along with the corresponding average Air Quality Index (AQI) for that period.

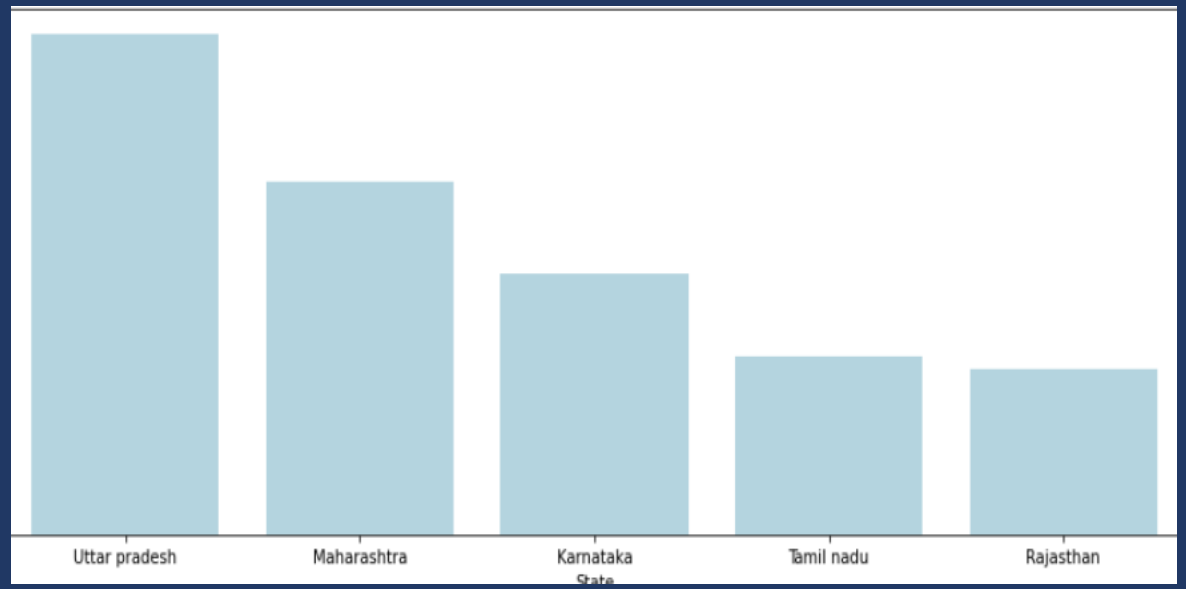
state	disease_illness_name	cases	rank	Aqi_value
andhra pradesh	acute diarrheal disease	1580	1	77.507701
andhra pradesh	food poisoning	602	2	77.507701
arunachal pradesh	cholera	125	1	54.485265
arunachal pradesh	acute diarrheal disease	123	2	54.485265
assam	acute diarrheal disease	1427	1	114.117456
assam	food poisoning	1217	2	114.117456
bihar	acute diarrheal disease	797	1	157.158122
bihar	fever with rash	523	2	157.158122
chhattisgarh	acute diarrheal disease	4351	1	78.986321
chhattisgarh	food poisoning	542	2	78.986321
delhi	dengue	40	1	206.416889
gujarat	acute diarrheal disease	2366	1	110.634272
gujarat	food poisoning	1692	2	110.634272
haryana	cholera	513	1	140.852806
haryana	acute diarrheal disease	322	2	140.852806

Top Diseases: **Acute diarrheal disease** and **food poisoning** are the most common illnesses across most states, often leading in case numbers.

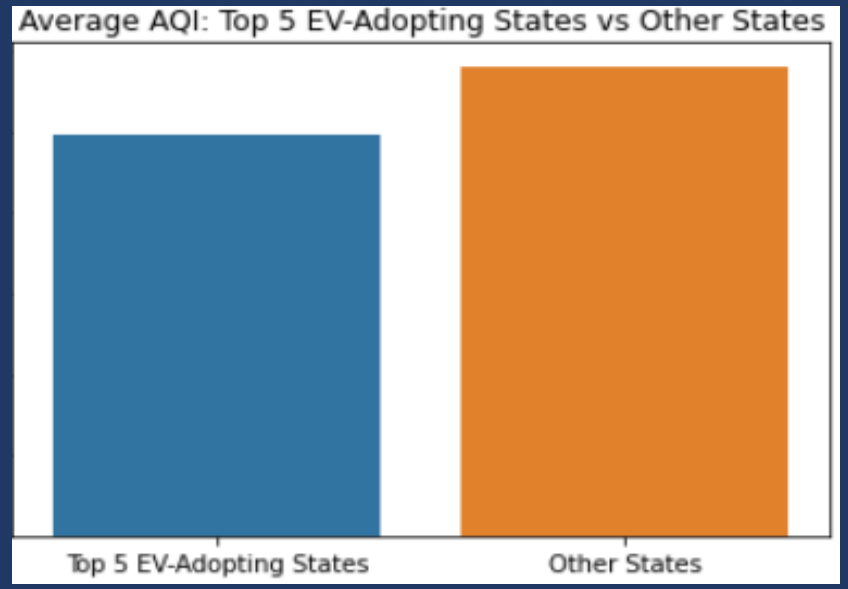
Air Quality Link: States with higher pollution (AQI) like Delhi and Bihar tend to have more severe health issues, indicating a possible connection between poor air and disease.

7.List the top 5 states with high EV adoption and analyze if their average AQI is significantly better compared to states with lower EV adoption

TOP 5 EV adoption State

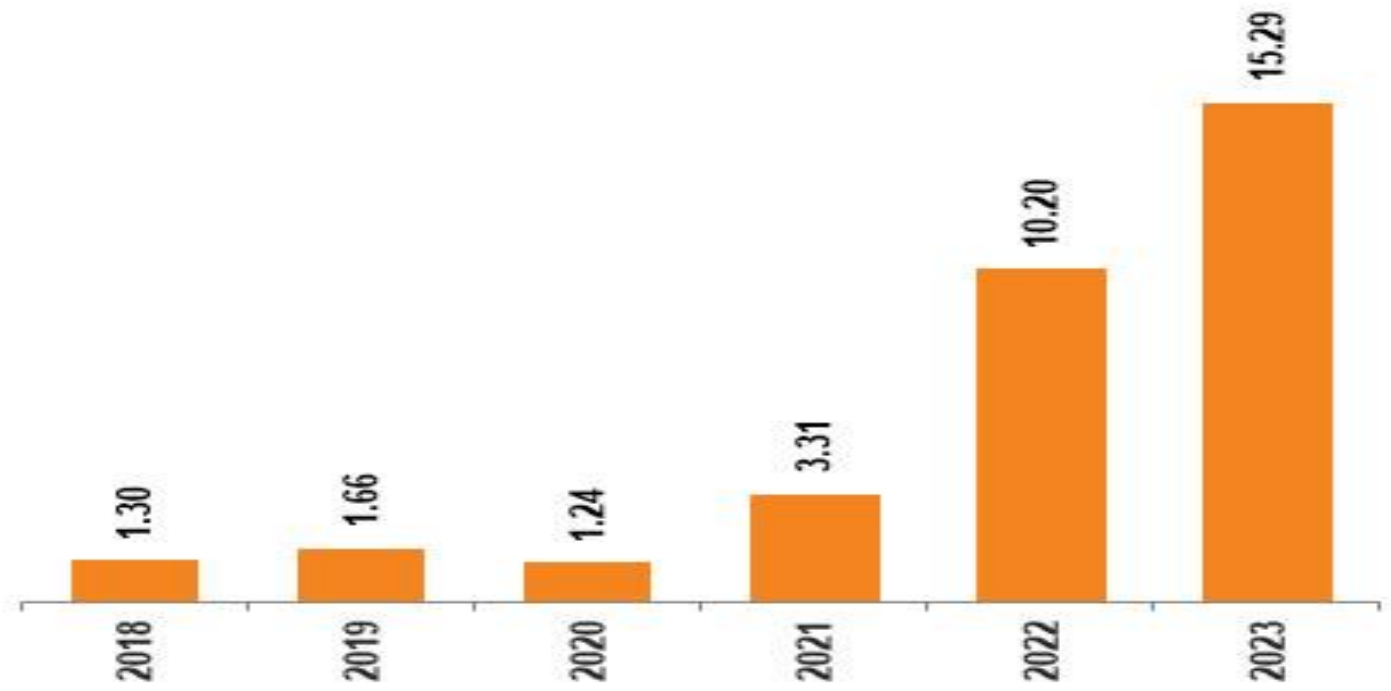


Aqi Value (EV-adoption vs other states



- Top 5 EV-Adopting States have a lower average value (99.29) compared to Other States (116.39),
- suggesting that states leading in electric vehicle adoption enjoy better air quality or lower pollution levels.

No. of Electric vehicle registered over the year (in millions)



Source: PIB

Secondary Analysis

1 . Which age group is most affected by air pollution-related health outcomes — and how does this vary by city?

City / Context	Most Affected Age Group(s)	Key Insights
All India (district-level)	Newborns & Children (<5 years)	Highest relative increases in mortality (86% f...
Delhi (short-term impact)	Elderly (60+ years)	Mortality increases significantly with $PM_{2.5}$ s...
Bengaluru (daily mortality rise)	Likely across age groups (not age-specific)	Highest short-term sensitivity (3.06% rise in ...
Delhi (annual burden)	Across age groups (population-level)	Highest total attributable deaths (~12,000/yea...
Shimla	Across age groups (population-level)	Lowest absolute burden (~59 deaths/year). Sour...

Parameter	Urban Area (Mean ± SD)	Rural Area (Mean ± SD)	*p*-value
AQI	182.5 ± 15.3	68.4 ± 12.1	<0.001
PM2.5 (μg/m³)	92.1 ± 8.7	34.7 ± 6.2	<0.001
PM10 (μg/m³)	142.3 ± 10.4	55.6 ± 7.8	<0.001
NO_2 (ppb)	41.6 ± 5.2	18.9 ± 3.4	<0.001
SO_2 (ppb)	17.3 ± 3.1	8.4 ± 2.1	<0.001

(*Source: Environmental Monitoring Station Data*)

- **Nationwide Trend:** Children under 5 years old, especially newborns, have the **highest relative mortality risk** from air pollution exposure in India.
- **Delhi (Age Sensitivity):** While the elderly (60>) are most vulnerable to **short-term pollution spikes**, the city's overall **annual mortality burden** from air pollution is the **highest in India**.
- **Bengaluru (Short-Term Impact):** Bengaluru records the **largest short-term mortality increase** linked to air pollution among major cities

- **Elderly Risk Factor:** Older adults are more likely to face **acute health crises** during sudden pollution increases, especially in Delhi and other high-AQI cities.
- **Health Disparities Across Cities:** While all cities experience air pollution-related health impacts, the **pattern of age-group vulnerability** differs based on pollution type, duration, and local environmental factors.

https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(24)00114-1/fulltext

2. Who are the major competitors in the Indian air purifier market, and what are their key differentiators (e.g., price, filtration stages, smart features)?

	Brand	Price Range (₹)	Min Price	Max Price	Market Segment	Filtration & Technology	Smart & Unique Features	avg_price
0	Philips	₹15,000–₹35,000	15000	35000	Mid-premium	VitaShield HEPA + Carbon	AeraSense sensors, ultra-quiet, auto modes	25000.0
1	Xiaomi (Mi)	₹10,000–₹20,000	10000	20000	Affordable smart	3-layer HEPA + Carbon pre-filter	OLED display, Wi-Fi/app control, high CADR	15000.0
2	Dyson	₹30,000–₹65,000	30000	65000	Premium	HEPA H13 + Carbon	360° air intake, voice & app control, design-led	47500.0
3	Honeywell	₹12,000–₹25,000	12000	25000	Mainstream	Pre-filter + HEPA + Carbon	PM2.5 display, silent mode, child-lock	18500.0
4	Daikin / Panasonic	₹20,000–₹40,000	20000	40000	Mid to high tier	HEPA/Carbon integrated tech	HVAC integration, global build quality	30000.0
5	Blue Star	₹14,000–₹50,000	14000	50000	Mid to premium	HEPA + Carbon + Cold Catalyst	Washable pre-filter, low noise, smart indicators	32000.0
6	Sharp	₹18,000–₹30,000	18000	30000	Mid-range	Plasmacluster ion + HEPA	Virus/mold removal, energy efficiency	24000.0
7	Coway	₹25,000–₹45,000	25000	45000	Premium Performance	HEPA H13 + Carbon + Ionizer	High CADR, whisper-quiet, long filter life	35000.0
8	Eureka Forbes / Kent / Voltas	₹7,000–₹30,000	7000	30000	Budget to mid	HEPA + Carbon filters	Local service reach, widespread availability	18500.0

https://www.business-standard.com/content/specials/high-pollution-and-aqi-levels-boost-air-purifier-sales-in-india-in-q3-2023-philips-leads-as-the-top-brand-123111600818_1.html

https://www.imarcgroup.com/india-air-purifier-market

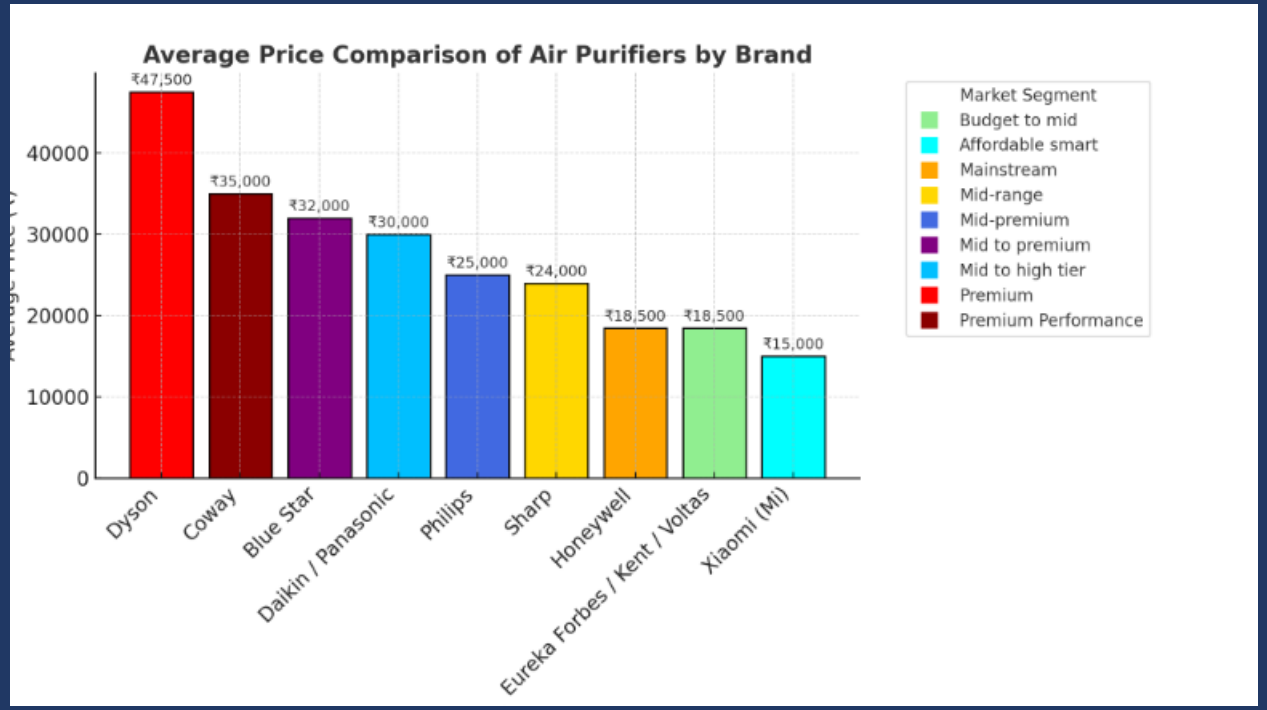
- **Price Segments**
  - Budget options start from ₹7,000 (Eureka Forbes/Kent/Voltas)
  - Premium options go up to ₹65,000 (Dyson)
  - Mid-range is around ₹15,000–₹35,000 (Philips, Sharp, Honeywell, etc.)

- **Market Leaders by Segment**
  - Premium: Dyson, Coway
  - Mid to Premium: Philips, Blue Star, Daikin/Panasonic
  - Affordable Smart: Xiaomi (Mi)
  - Budget: Eureka Forbes/Kent/Voltas

- **Filtration Technologies**
  - Most use HEPA + Carbon combinations.
  - Premium brands (Dyson, Coway) use HEPA H13 (higher-grade) and extras like ionizers or 360° intake.
  - Sharp uses Plasmacluster ion tech for virus/mold removal.

- **Smart/Unique Features**
  - Premium models include voice & app control, 360° intake, and long filter life.
  - Affordable smart models (Xiaomi) have OLED display, Wi-Fi control, and high CADR.
  - Features like PM2.5 display, child-lock, and silent modes appear in mid-range models.

- **Average Price Leaders**
  - Highest avg price: Dyson (~₹47,500)
  - Lowest avg price: Eureka Forbes/Kent/Voltas (~₹18,500) among non-ultra-budget
  - Balanced mid-premium pricing: Philips (~₹25,000)



3 .What is the relationship between a city's population size and its average AQI — do larger cities always suffer from worse air quality? (Consider 2024 population and AQI data for this) ¶

	City	Population_2024	Average_AQI	AQI_Category	Pollutants	Severity_Score	Notes_Cleaned
0	Delhi	33807403	350	Hazardous	PM2.5,PM10	10	Worst air quality in India
1	Mumbai	21673149	130	Moderate	PM2.5,NO2	5	Coastal city better than Delhi
2	Kolkata	15570786	175	Unhealthy	PM2.5,SO2	7	High industrial activity
3	Bangalore	14008262	100	Moderate	PM2.5	4	Better air quality in south
4	Chennai	12053697	90	Moderate	PM2.5,NO2	4	Coastal influence
5	Ahmedabad	8854444	135	Moderate	PM2.5,SO2	5	Growing industrial city
6	Surat	8330528	145	Unhealthy	PM2.5,SO2	6	Textile and industrial hub
7	Pune	7345848	95	Moderate	PM2.5	4	Urban pollution
8	Jaipur	4308510	125	Moderate	PM2.5	5	Increasing pollution
9	Aizawl	265331	20	Good	PM2.5	1	Clean air city in Northeast

- **Delhi** has the worst air quality (AQI 350, hazardous) and highest severity score, making it the top public health concern.
- **Industrial hubs like Kolkata** and Surat face unhealthy AQI due to high $PM_{2.5}$ and SO_2 emissions.
- Most major cities (**Mumbai, Bangalore, Chennai, Ahmedabad, Pune, Jaipur**) fall under the moderate AQI range (90–145).
- Aizawl has the cleanest air (AQI 20) with minimal pollution sources.
- **$PM_{2.5}$** is present in all cities, confirming it as the primary pollutant nationwide.
- **SO_2** is linked to industrial activity, while NO_2 is tied to vehicle emissions in coastal and urban centers.
- Coastal cities benefit from natural air dispersion, improving AQI compared to inland northern plains, which suffer from dust, stubble burning, and industrial emissions.
- Population size worsens the health impact — Delhi's large population + poor AQI make it the most at-risk city.

4. How aware are Indian citizens of what AQI (Air Quality Index) means — and do they understand its health implications?

	Aspect	Findings
0	General Awareness	Over 90% of respondents in major Indian cities...
1	Understanding of AQI & Pollutants	Awareness of AQI ~54%, PM2.5 ~29.6%, PM10 ~17....
2	Health Impact Awareness	People recognize air pollution harms health, b...
3	Protective Behaviour	Few take individual measures (e.g., masks, avo...
4	Information Channels	Govt initiatives like SAFAR app, NAQI portal, ...
5	Barriers to Understanding	Technical language and complex data presentati...

Reference links 🔗🌐

https://www.teriin.org/sites/default/files/2018-03/perception-survey-results.pdf
https://cpcb.nic.in/National-Air-Quality-Index/
https://www.airquality.cpcb.gov.in/ccr_docs/About_AQI.pdf

- **High general awareness, but low technical understanding** — while over 90% know about air pollution, fewer than 55% understand AQI, and awareness of specific pollutants like $PM_{2.5}$ (29.6%) and PM_{10} (17.8%) is much lower.
- **Health impact knowledge is shallow** — people know pollution harms health but lack clarity on AQI thresholds, exposure levels, and associated risks.
- **Low adoption of protective behavior** — even concerned individuals rarely take preventive actions like wearing masks or limiting outdoor exposure.
- **Information channels exist but aren't widely used — government tools (SAFAR app, NAQI portal) and campaigns have limited public penetration.**
- **Communication barriers hinder understanding** — technical jargon and complex AQI data presentation reduce accessibility; localized, simplified messages are scarce.

5. Which pollution control policies introduced by the Indian government in the past 5 years have had the most measurable impact on improving air quality — and how have these impacts varied across regions or cities?

Key Air Pollution Control Policies & Their Impact

- **National Clean Air Programme (NCAP) (2019)**
Launched to reduce particulate matter (PM) pollution by up to 40% in 131 cities with poor air quality. Cities like Mumbai and Kolkata have shown significant improvements, with PM_{10} levels dropping by 44% and 37%, respectively. However, progress has been uneven—cities like Delhi and Faridabad have struggled due to underutilized budgets and challenges in implementation.

- **SAFAR (System of Air Quality Forecasting & Research)**
Provides real-time air quality data and short-term forecasts (1 to 3 days) in metros such as Delhi, Mumbai, Pune, and Ahmedabad. This enables authorities and citizens to take timely preventive actions, improving public health and lowering medical costs.

- **Bharat Stage VI (BS-VI) Emission Norms (2020)**
A major upgrade in vehicle emission standards that reduces harmful pollutants like nitrogen oxides (NO_x) and particulate matter (PM), aligning India's vehicle standards with global benchmarks.

- **Petrol and Diesel Vehicle Ban Proposal in Mumbai**
Maharashtra is considering banning petrol and diesel vehicles in Mumbai to replace them with electric or cleaner alternatives, supporting better air quality goals.

- **Emission Control Challenges in Maharashtra's Coal Power Plants**
Many coal-fired power plants received exemptions from installing pollution control devices like Flue Gas Desulfurization (FGD) systems as of July 2025. This risks increased $PM_{2.5}$ and SO_2 emissions, undermining air quality improvements.

https://timesofindia.indiatimes.com/india/103-cities-show-drop-in-pm10-levels-under-clean-air-programme/articleshow/122822133.cms

https://energyandcleanair.org/publication/tracing-the-hazy-air-2025-progress-report-on-national-clean-air-programme-ncap/

Priority Cities: Which Tier 1/2 cities show irreversible AQI degradation?

- **Delhi** – Among the worst globally; annual $PM_{2.5}$ levels have been rising, consistently ranking as one of the most polluted major cities.

- **Greater Noida, Sri Ganganagar & other UP/Rajasthan hubs** – Very high annual PM_{10}/$PM_{2.5}$ levels in 2024 NCAP reports, exceeding national standards year after year.

- **Industrial/Urban clusters (e.g., Ahmedabad/Vapi, Pune/PCMC)** – Frequent "poor" AQI days due to structural sources like industry, transport, and dust; not just seasonal spikes.

- **Pattern** – Pollution in these cities is persistent and structural, not one-off; urgent interventions needed

https://www.iqair.com/us/newsroom/5-most-polluted-major-cities-in-world-2024?utm_source=chatgpt.com

https://energyandcleanair.org/publication/tracing-the-hazy-air-2025-progress-report-on-national-clean-air-programme-ncap/

https://timesofindia.indiatimes.com/city/ahmedabad/gujarat-had-53-days-of-poor-air-quality2025/articleshow/123194857.cms?utm_source=chatgpt.com

Health Burden: How do AQI spikes correlate with pediatric asthma admissions?

•**Multiple epidemiological studies show short-term increases in $PM_{2.5}$/PM_{10}/NO_2/SO_2 are associated with increased hospital admissions for asthma and pneumonia in children (lagged effects of 1–4 days are commonly reported). This is consistent across multi-city analyses.**

•**Real-world signals: rising pollution years have coincided with reported increases in respiratory visits and insurance/claim pressures in major cities (e.g., insurers in New Delhi noting higher claims tied to pollution). This aligns with the literature linking spikes to pediatric morbidity.**

Conclusion: There is robust evidence that AQI spikes — especially $PM_{2.5}$ — lead to measurable increases in pediatric asthma and respiratory hospitalizations within days. Prioritizing pollution reduction in high-exposure cities will directly reduce child morbidity.

https://www.reuters.com/world/india/india-insurers-look-hike-health-premiums-pollution-stings-2025-02-21/?utm_source=chatgpt.com

Behavior shifts — do pollution emergencies increase purifier searches/purchases?

•Market and industry reports show rapid growth in the air purifier market (India market projected to grow strongly; global market rising), and analysts explicitly note seasonal/episodic spikes in sales tied to smog seasons and wildfire/Diwali events.

News/analysis from previous severe pollution events (Diwali/smog periods) documents surges in online searches and short-term spikes in retail demand for purifiers and masks. This consumer behavior is repeatable and often drives temporary demand booms.

Conclusion: Yes — pollution emergencies reliably cause spikes in purifier interest and purchases (seasonal demand spikes). This creates windows for public-private interventions (subsidies, deployment of community units) but also means private demand alone doesn't solve ambient pollution.

https://www.aqi.in/blog/diwali-air-quality-report-2024

https://www.marketsandata.com/industries

Feature Gaps in Existing Air Purifiers

Based on market reports and industry feedback:

- **Smart AQI syncing**: Many purifiers rely on onboard sensors that vary in accuracy and aren't calibrated to official or city AQI standards. There's no universal syncing with trusted public air quality data.

- **Compact, high-performance design**: Efficient models are often bulky or noisy, limiting usability in small urban homes.

- **Cost of ownership (TCO)**: High filter replacement and energy costs reduce long-term affordability for many consumers.

- **Lack of advanced sensors**: Few affordable units include $PM_{2.5}$ plus VOC sensors; many ignore other pollutants (e.g., CO_2) or lack validated calibration.