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Studies of Air Pollution And Health

Dr. Akhila Udupa
Associate Professor,
Master In Business Administration (General Management), Presidency University, Bangalore, India,
Email Id:akhila.udupa@presidencyuniversity.in

The health impacts of air pollution have been widely researched using a variety of study approaches, including epidemiological, level of exposure, animal, and other toxicological investigations. Each strategy has advantages and disadvantages, and developing a clear picture of how air pollution impacts health requires an analysis of data from alternative study approaches. Epidemiological studies look at the association between air pollutant concentrations and health outcomes in real-world situations, usually with high populations in community settings. While people's activity patterns that is, time spent in various contexts such as work and home influence their individual exposures, air pollution monitoring data are often used as surrogacy for individual exposure. Health outcomes are often examined using public health databases, interviews, or pulmonary function testing [1]–[3]. A seminal research of air pollution and mortality in six U.S. cities, for example, recruited students and adults and used outside monitors in each city to assess exposure to air pollution. Individuals in the most contaminated cities had a 26% higher death rate than those in the least polluted cities.

The American Cancer Society's Cancer Prevention Study CPS II monitored over 500,000 people in 151 U.S. urban regions. This study additionally made use of aggregate-level exposure data as well as individual-level health information. The researchers discovered that individuals in the most contaminated locations died at a 17 percent greater rate than those in the least urbanized ones. The utilisation of real-world populations and air quality concentrations is a significant benefit of epidemiological investigations. Epidemiological studies, on the other hand, may be hampered by their inability to adequately account for confounding variables such as temperature, weather, demographic characteristics, the presence of contaminants, and the difficulty of precisely assessing personal exposure. In general, random error in exposure assessment reduces the sensitivity of epidemiological research in identifying impacts. Confounding may cause the apparent impact of air pollution to be incorrectly increased or decreased.

In controlled human exposure studies, volunteers are exposed to a certain concentration of an air pollutant or pollutant combination in a laboratory environment and their health responses are measured. Exposure studies, as opposed to epidemiological research, may account for any confounding variables, provide a precisely described exposure, and combine very intrusive and complicated methodologies for outcome evaluation. To ensure the safety of participants, such study looks at health impacts that are modest, acute, and reversible. Human exposure studies, for example, may study heart rate variability, lung function changes, and the proportion of particles deposited in the lung. Exposures are often brief and at low concentrations. Human exposure trials are not appropriate for studying chronic health consequences or more serious health outcomes. These investigations, on the other hand, are especially important for identifying damage processes in order to bridge from animal to human research and for determining threshold concentrations for short-term effects.

Animal experiments incorporate either short-term or long-term exposure to a pollutant combination under controlled settings. Animals are occasionally exposed to outside pollutants and even put in high-traffic areas, such as beside highways. Invasive evaluation methods, such as lung biopsies, are sometimes used in animal investigations. Biological samples might be gathered for a thorough examination of an injury mechanism. When extrapolated to humans, findings from animal research may be prone to ambiguity, and responses may differ even within animal species [4], [5].

Particulate Matter

Particulate matter PM is a broad category of pollution rather than a specific, individual pollutant having a specific chemical structure, such as SO2. The phrase particulate matter refers to solids as well as liquids that remain in the air, regardless of their chemical makeup. This pollutant may be either primary or secondary produced in the atmosphere by physical and chemical conversion of gaseous precursors such as NOx, SOx, and VOCs. PM is produced by the combustion of fuel for example, power plant emissions, unpaved roads, industry, and wood-burning stoves, as well as natural sources such as pollen, dust, salt deposits, erosion, and mould. PM concentrations might vary within a region or even within a city depending on their proximity to different PM sources. The composition of particulate matter varied by geographic location and may also svary with season, source, and weather. In the eastern United States, PM often shas a considerable sulphate component, reflecting the effects of emissions from spower plants. In the western United States, traffic emissions contribute a larger proportion of PM, typically generating a considerable nitrate component. In the U.S. Northwest, wood burning may be a significant source of PM during colder seasons. Windblown dust may be a substantial source of PM in desert regions such as are found in the southwestern United States.

A particles size is connected to its source. The size influences how it is carried in the atmosphere, where it is placed in the environment, and where it is deposited in the respiratory system. Smaller particles are of specific health concern since they penetrate more deeply into the lung. Those particles are typically created by combustion processes. Diesel exhaust, a combination of gases and particles, is of special concern because of ubiquitous diesel use sand since these particles are exceedingly tiny In addition, the gas of diesel includes several dangerous air pol emergency room admissions, respiratory symptoms, loss in pulmonary function, worsening of chronic respiratory and cardiovascular disorders, and spremature death. EPA, 2003. Experimental animals exposed to PM experienced variety of reactions, including inflammation and lung damage. Time series studies, which track day-today variation in PM levels and in mortality, have shown that acute PM exposures is associated with increased mortality, which peaks within a few days of exposure, reminiscent of the London and Donora episodes described earlier but occurring even at todays lower levels of PM exposure Longitudinal studies like as the Six Cities research and CPS II A National Research Council panel recently assessed the status of this evidence. Rules for PM have developed in response to a deeper knowledge of show PM impacts human health. When the initial National Ambient Air Quality Standard for particulate matter was created in 1971, it addressed total suspended material TSP, but this standard was replaced with one for PM10 when sit became obvious that these smaller particles were more closely related with health. Subsequent data revealed that even tiny particles, PM2.5, were responsible for detrimental health impacts, and a PM2.5 threshold was adopted in 1997. Future study will clarify the impacts of PM and will likely have an influence on regulations as well [3], [6].

Nitrogen Oxides

Nitrogen oxides NOx are a class of extremely reactive gases that include nitrogen. Nitrogen and oxygen are combined to form nitrogen dioxide NO2 and nitric oxide NO. These Pollutants react in the atmosphere, producing new pollutants and hazardous chemicals such as nitroarenes. NOx is created during combustion, which includes as fossil fuels are burned, the nitrogen that makes up over 80% of the air is released. oxidised. Car and truck engines, power utilities, and factories are therefore NOx sources. NO2 may also be produced by indoor air pollution. Kerosene heaters, unvented gas stoves and heaters, and cigarette smoke are all sources of pollution. Natural

NOx sources include stratospheric intrusion NOx entering the troposphere. The main sources nowadays are power plants and motor vehicles, but they also come from the stratosphere, biological processes in the soil, forest fires, and lightning. In the United States Motor vehicles presently account for half of all NOx emissions in the United States. NO2, like ozone, is virtually insoluble in water and may enter the lower respiratory tract. NO2s health impacts include eye, nose, and throat discomfort. Short-term reductions in lung function and possible death at higher doses Childrens respiratory illnesses and symptoms have risen. It is challenging to Separate the impacts of NOx from those of other air pollution components like ozone. as well as particle stuff. NO and NO2 both NO2 is controlled as a criterion pollutant under the Clean Air Act. Act. Nitrogen oxides have an indirect but significant impact as a precursor. NOx is a pollutant. It is a precursor of tropospheric ozone and secondary particulate matter and plays an important role in acid precipitation production. N2O nitrous oxide is a greenhouse gas a greenhouse gas that contributes to global warming NOx and the pollutant species generated as a result of chemical reactions have the ability to travel large distances. As a result, health impacts may occur far from the cause. Despite the fact that emissions have decreased, decreased in recent decades, by around 15% between 1983 and 2002, Certain sources of pollutants, such as off-road vehicle engines, are increasing [4], [7].

Volatile Organic Compounds

VOCs are a class of organic compounds with a high vapour pressure that evaporate easily at room temperature and pressure. Benzene, chloroform, formaldehyde, isoprene, methanol, and monoterpenes are among the hundreds of chemicals. VOCs are emitted by natural sources such as oak and maple trees, power plants and industrial operations such as those involving chemicals and solvents, and transportation, which includes motor vehicles and off-road vehicles such as aero planes, construction equipment, and lawn mowers. Motor vehicle emissions account for roughly 75% of transportation-related VOC emissions, with the majority of these emissions coming from the approximately 20% of older and poorly maintained cars EPA, 1996. Biogenic sources contribute more to VOCs than human emissions in many regions. For example, in 1990, biogenic VOC emissions accounted for 77% of VOC emissions in the mid-Atlantic area . The natural look that lends the Blue Ridge and Great Smoky Mountains their names is caused by biogenic VOCs that generate aerosols. VOCs are ozone precursors, but they also have independent health consequences such as respiratory tract irritation, headaches, and carcinogenicity.

Tropospheric Ozone

Ozone may be found in the troposphere, the lowest atmospheric layer that extends from the troposphere to about 10 to 15 kilometers above the earth's surface, and the stratosphere, which extends from the troposphere to about 45 to 55 kilometres above the earth's surface. The naturally occurring ozone layer that shields the earths surface from UV radiation is formed by tropospheric ozone, while tropospheric ozone, also known as ground level ozone, is a dangerous contaminant. The EPA has proposed the tagline Good up high bad close to highlight the distinction between stratospheric and tropospheric ozone. Tropospheric ozone is a colourless gas and a photochemical oxidant generated in the presence of sunlight by complicated, nonlinear chemical processes involving the precursors VOCs and NOx. As a consequence, ozone pollution is frequently referred to as photochemical smog. Ozone from the stratosphere may also enter the troposphere. Controlling ozone levels is a challenging problem due to the complicated chemistry that produces ozone. Reduced NOx or VOC emissions may result in increased ozone levels, depending also on baseline concentrations of the two primary groups of precursors, among other considerations. Reducing NOx emissions may be the most effective strategy to decrease ozone levels in NOx-limited places, whilst lowering VOC emissions are more successful in VOC-limited areas.

Ozone concentrations are extremely seasonal, with larger levels emerging during the hotter months; they also exhibit significant diurnal rhythms, following the cycles of sunlight and vehicle emissions. Because of their closeness to ozone precursor emissions, urban areas have greater ozone concentrations. After the emission of ozone precursors, they may flow downwind in an expanding plume and contribute to the creation of ozone, which can then migrate following wind patterns. As a consequence of the transmission of ozone and its precursors hundreds of kilometres distant, high concentrations may occur. Ozone concerns are often regional rather than localised. Since ozone adsorbs to interior surfaces and degrades quickly, ozone levels are often lower inside than outside.

Ozone is not particularly soluble in water, which allows it to enter the lower respiratory tract. Ozones oxidant qualities allow it to disrupt molecular bonds and swiftly harm human tissue. Short-term ozone exposure has been linked to temporarily impaired lung function, increased airway resistance, and increased respiratory symptoms such as coughing and wheezing in healthy persons. After high-ozone days, there is an increase in clinic visits, emergency department visits, school absences, and hospitalizations. Ozone was additionally linked to early mortality. Since ozone inflames the airway linings and may precipitate asthmatic episodes, people with asthma are more vulnerable to its effects. Yet, healthy non asthmatics might be impacted as well. Children with restricted calibre airways are likewise more vulnerable. Individuals who spend time outside, like those who exercise or work outside, are more vulnerable due to increased ozone exposure. Long-term ozone exposure may lead to the development of chronic lung disorders including asthma and bronchitis, as well as hasten lung ageing. Ozone levels have also been linked to poor lung development in youngsters.

Carbon Monoxide

Carbon monoxide is a colourless, odourless gas that results from the incomplete combustion of carbonaceous materials such as petrol, natural gas, oil, coal, tobacco, and other organic components. Motor vehicles generate the bulk of CO emissions to outdoor air; hence CO concentrations are greater in regions with high traffic density and during peak traffic periods. Carbon monoxide levels may also be elevated in densely populated metropolitan areas with slow-moving traffic. Vehicles produce more CO while they are idle or driving slowly in cold weather. Off-road vehicles and wildfires are two more factors. In certain regions, wood burning also creates large CO emissions. High CO levels are more common during colder months due to increasing automobile emissions and inversion conditions that hinder pollutants from dissipating.

Leaded Gasoline and Blood Lead Levels in the United States

The removal of lead from petrol is one of the most significant and effective environmental health efforts of the twentieth century, demonstrating the successful motivating of legislation and policy by epidemiological studies to promote human health. Three General Motors engineers reported in December 1921 that adding tetraethyl lead TEL to motor vehicle fuel improved engine performance and decreased engine knock, and TELspiked gasoline was put into the US fuel market in 1923. Within a year of the widespread usage of leaded petrol, the fatal potential of TEL became apparent when employees engaged in the additives manufacture became ill and died at multiple refineries in New Jersey and Ohio. This lead poisoning epidemic prompted the United States Surgeon General to temporarily suspend the production and sale of leaded gasoline in 1925; he then appointed a panel of experts to investigate the recent fatalities and assess the potential danger that might arise from the widespread distribution of lead via its sale as a gasoline additive.

The panel decided that there was no need to ban leaded petrol if its distribution and usage were controlled. Unfortunately, developing such restrictions was not a top priority throughout the subsequent decades of depression, war, and postwar expansion. It wasnt until the early 1970s, with the passage of the Clean Air Act, that the United States Environmental Protection Agency moved to decrease lead levels in gasoline in order to accommodate catalytic converters that were fouled by lead. Around this time, evidence of the negative health consequences of chronic, low-level lead exposure was also developing. The United Nations Committee on Sustainable Development recommended for the global abolition of leaded petrol in 1994. Lead levels in the blood have been proven to decrease when lead compounds in petrol are removed. Numerous nations, including Canada, Argentina, the United States, and Japan, have already phased out or intend to phase out leaded petrol. Nonairborne sources of lead, such as ingestion of leaded paint, provide a greater health risk in these nations than airborne lead.

Nonetheless, lead additives are still widely used in other parts of the world, including several African nations. Metal processing, lead metals, waste incineration, and lead battery manufacturing and reclamation are all sources of atmospheric lead. Even at modest amounts, lead may be detrimental because it accumulates in the body, primarily in the bones, which then serve as continual internal sources of exposure. Lead absorption is affected by physiological factors such as health, age, and dietary condition. Leads health consequences have been widely researched. Lead poisoning may harm the neurological system and kidneys, as well as interfere with red blood cell production, reproductive function, and gastrointestinal function. Children and pregnant women are especially susceptible because lead exposure affects the developing neurological system.

Air Toxics

In addition to the contaminants previously mentioned, there are hundreds more in the atmosphere. To mention a few, these are hydrochloric acid, captan, parathion, naphthalene, biphenyl, vinyl bromide, toxic metals, dioxin, and cadmium. These contaminants may be inhaled, but they can also infiltrate other environmental media such as water and food. As a result, exposure may occur by eating contaminated foods, drinking polluted water, or coming into touch with soil contaminated by air deposition. These air toxics health consequences include neurological, immunological, respiratory, and sexual for example, lower fertility, as well as developmental issues and certain malignancies. Animals, like people, may develop health issues if exposed to high levels of air toxics. Certain air toxics accumulate in tissues, causing concentrations in aquatic or marine species to exceed those in the surrounding air and water. One kind of contaminant is polychlorinated biphenyls PCBs. Concentrations rise higher along the food chain, for example, when bigger fish consume infected smaller fish.

Mercury

Mercury occurs naturally, but human activities may cause it to be discharged into the atmosphere, land, or water. Since mercury is widely found in coal, atmospheric mercury may be deposited in bodies of water, transformed into methylmercury by bacteria, and then ingested by fish. Since mercury accumulates in tissues, fish, particularly those upper in the food chain, such as shark, swordfish, and king mackerel, may have high mercury amounts. Mercury may be passed on to humans when they ingest this fish. The US Food and Drug Administration 2001 issued an advisory advising nursing women, pregnant women, and women of childbearing age who might grow pregnant to avoid eating shark, swordfish, king mackerel, and tilefish, and to limit their intake of other types of fish to no more than twelve ounces per week. The nutritional advantages of seafood must be balanced against the health risks of mercury consumption. Mercury affects the neurological system, causing blurred vision and coordination, memory loss, personality changes, and, in rare cases, death, as well as the kidneys. Children and foetuses are especially vulnerable to mercury poisoning.

Air Pollution Prevention and Control

There are various stages between ambient air pollution and human health. Pollutant or precursor release from the source Pollutant or precursor transport in this example, through air, as well as probable chemical and physical change. Exposure through inhalation or, in certain situations, other media after pollution deposition in the atmosphere Air pollutions health consequences may be mitigated at any of these stages. Primary prevention is the ideal method to limiting the health impacts of air pollution, as it is in many other areas of environmental health. For air pollutants, this entails lowering pollutant or precursor emissions at the source. This technique might include building scrubbers to remove SO2 from gaseous emissions, lowering power consumption, burning low-sulfur coal rather than high-sulfur coal, or switching to cleaner fuel sources entirely and generating electricity from wind, sun, or water. Primary prevention efforts for vehicle emissions include reducing the number of miles travelled via transportation demand management, such as telecommuting and carpooling driving cleaner, more efficient vehicles, using cleaner fuels, promoting public transportation, and implementing inspection and maintenance programmes.

Regulatory Approaches

The Clean Air Act is largely responsible for regulating air pollution, and various significant methods to control have emerged. Initially, restrictions are defined on the maximum permitted quantities of pollutants in certain places. Second, emissions from sources such as industries and power plants are limited. Finally, polluters may be obliged to employ certain technology to reduce their emissions. Fourth, market-based incentives may be used to encourage polluters to reduce their emissions. Lastly, in order to incentivize reduction, rules may compel public publication of information concerning emissions. All of these technologies are used in a complicated regulatory framework by the Clean Air Act and associated laws. Ambient standards are restrictions on the concentration of certain contaminants in outdoor air, which may necessitate emissions reductions in polluted regions. The National Ambient Air Quality Standards are a great example of limitations on ambient air pollution levels NAAQS. For the following contaminants, ambient limits have been established: O3, SO2, PM, lead, NO2, and CO. The criterion pollutants are so termed because the EPA is mandated to evaluate the NAAQS and relevant scientific findings at least every five years and adjust the limits if necessary. For criteria pollutants, there are two types of NAAQS: primary standards, which are intended to protect human health with an adequate margin of safety, not only for the general population but also for vulnerable populations such as children and the elderly; and secondary standards, which are intended to protect welfare concerns such as the environment, visibility, and property damage. States having areas that do not meet the NAAQS, known as nonattainment areas, must produce and submit to the EPA a state action plan SIP explaining how the state intends to achieve compliance.

The fact that ambient regulations cannot protect everyone because to the variety of sensitivity is a significant characteristic. Notwithstanding the need to safeguard public health with a margin of safety, standard setting is a political process including compromises. Moreover, increasing scientific information sometimes indicates that previously regarded safe amounts of exposure may really pose some danger. For example, ozone exposure has been demonstrated to impair lung function in certain persons at levels as low as 40 parts per billion, far under the safe exposure limits set by the EPA. Several contaminants and sources have emission standards. Emissions regulations restrict the quantity of polluted air that may be produced from a certain source, such as limiting the amount of CO generated by motor vehicles and requiring permits for big stationary sources. This is the primary approach to hazardous or toxic pollutants, which are not criterion pollutants yet cause substantial health and environmental harm. VOCs, pesticides, herbicides, and radionuclides are among the 188 contaminants now listed. Carcinogens include benzene, vinyl chloride, toluene, and chloroform. While hazardous pollutants come from a variety of sources, the majority of them come from industry and waste products. Specific rules for various sorts of sources, such as chemical factories and oil refineries, govern hazardous pollutants.

Technological requirements are another method of regulation. The EPA uses this method to advise polluters not just how much they may release, but also what strategies they must adopt to decrease emissions. These specifications are known as best available control technology BACT and maximum attainable control technology MACT MACT. These techniques are often employed in conjunction with emission requirements. The National Emissions Standards for air pollutants that are hazardous NESHAP, for example, are established at a level designed to offer an appropriate margin of safety to safeguard public health, given the best available control technology and taking into account cost and non-health consequences. The MACT is described as the technology that will provide the greatest possible reduction in emissions. Catalytic converters on autos are one example of a technological need. Traditional command-and-control rules are increasingly being supplemented, and in some instances replaced, by market-based regulatory systems. Emissions-trading schemes, for example, impose a limit on the total quantity of a pollutant that may be released while allowing various polluters to sell permits.

The goal is to obtain the most cost-effective distribution of emissions reductions by enabling facilities to pick their own equipment and design and by introducing financial incentives for higher performance than standard emissions laws would demand. This so-called cap-and-trade system might drive the development of new equipment that enables better air quality management by converting zero tailpipe emissions into a financial asset. The SO2 allowances system under the EPAs Acid Rain Program and the Regional Clean Air Incentives Market are two significant cap-and-trade schemes. The South Coast Air Quality Management District implemented RECLAIM in 1993 to decrease ozone and particulate matter levels in southern California by reducing NOx and SOx emissions. Facilities that decrease their yearly emissions below their objectives might sell their unused pollutant rights to other facilities. Moreover, the bubble method is employed in calculating emissions, which implies that all emissions from a facility are assessed collectively, as opposed to the command-and-control technique, which governs each piece of equipment and process separately. Another example of a cap-and-trade policy is the Northeastern United States regional NOx programme, which was created to combat ozone.

Cap-and-trade regimes may be troublesome when the harmful impacts of pollution are localised or cumulative. Shifting emissions from one location to another may result in hot patches of damage near higher-emission sources. Another factor to consider in carbon trading schemes is transaction costs, which, if large, may reduce the overall economic effectiveness of the programme and impede trade. Lastly, information requirements are a different regulatory strategy. The Toxics Release Inventory TRI of the Environmental Protection Agency EPA is an annual public report on harmful chemical emissions and associated activities for specific companies and government facilities. The general public may obtain this information and learn about the air pollution emissions from their local facilities. States have the authority to impose standards that are more stringent than federal restrictions. The state of New York, for example, mandates power plants and other stationary sources to decrease NOx emissions below the federal limit, and many states have special standards for car emissions, such as the California Low Emission Vehicle programme. Currently, over thirty countries as well as the District of Columbia have automobile inspection and maintenance programmes, with varying frequency and stringency requirements [1], [2], [8].

Technological Controls

Changes in technology, such as the use of alternative technology such as public transportation instead of individual automobiles, modification of existing technology such as switching to low-sulfur coal, or the development of new, cleaner technologies, can be used to reduce ambient air pollution levels. Such technology advancements are fundamental environmental health prevention methods. The catalytic converter is an example of a technical air quality control. Catalytic converters, which convert CO, hydrocarbons, and NOx into less toxic compounds and thereby lower emissions, were first installed in automobiles in the 1970s. Despite an increase in vehicle miles driven, the deployment of the catalytic converter and innovations in its design allowed ambient CO levels to fall. CO emissions in the United States fell by almost half between 1970 and 1990. Nonetheless, places with heavy traffic might still have increased CO levels. Coal usage as a residential heating source has fallen in several nations, including the United Kingdom, leading CO levels to fall. Emulsified fuels, dust suppression and soil stabilization technologies that prevent particulate matter from becoming airborne, diesel engine emission controls, baghouse filtration products, and scrubbers are some examples of technical innovations that minimise air pollution.

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