AMBIENT AIR POLLUTION: A GLOBAL ASSESSMENT OF EXPOSURE AND BURDEN OF DISEASE

A WHO Report Summary

ABSTRACT

Air pollution has become a growing concern in the past few years, with an increasing number of acute air pollution episodes in many cities worldwide. Air pollution, both ambient (outdoor) and household (indoor), is the biggest environmental risk to health, carrying responsibility for about one in every nine deaths annually. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide.

SUDEEP UPRETY AND BIPUL LAMICHHANE

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BACKGROUND

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide.

Air pollution has become a growing concern in the past few years, with an increasing number of acute air pollution episodes in many cities worldwide. Air pollution, both ambient (outdoor) and household (indoor), is the biggest environmental risk to health, carrying responsibility for about one in every nine deaths annually. Ambient (outdoor) air pollution alone kills millions of people each year, mainly from non-communicable diseases. Exposure to air pollutants can affect human health in various ways, leading to increased mortality and morbidity. Epidemiological evidence on the health effects of air pollution is growing and evolving quickly. Today, air pollution is the largest environmental risk factor.

Air pollution has also been identified as a global health priority in the sustainable development agenda is used as a marker of sustainable development. Air pollution levels in cities is cited as an indicator for urban sustainable development (SDG 11); access to clean energy , particularly clean household fuels and technologies, is highlighted as an indicator for sustainable energy (SDG 7); and mortality due to air pollution (ambient and household) is used an indicator for the health SDG goal (SDG 3).

Air pollution affects all regions, settings, socioeconomic groups, and age groups. While all people living in a given area breathe from the same air, there are nevertheless important geographical differences in exposure to air pollution. Citizens in Africa, Asia or the Middle East breathe much higher levels of air pollutants that those in living other parts of the world.

In developing countries, indoor exposure to pollutants from the household combustion of solid fuels on open fires or traditional stoves increases the risk of acute lower respiratory infections and associated mortality among young children; indoor air pollution from solid fuel use is also a major risk factor for cardiovascular disease, chronic obstructive pulmonary disease and lung cancer among adults.

GLOBAL FACTS

Air pollution is a major environmental risk to health. Ambient air pollution in both cities and rural areas was estimated to cause 3 million premature deaths worldwide in 2012. In 2014, 92% of the world population was living in places where the WHO air quality guidelines levels were not met. About 88% of those premature deaths occurred in low- and middle-income countries, and the greatest number in the WHO Western Pacific and South-East Asia regions. In addition to outdoor air pollution, indoor smoke is a serious health risk for some 3 billion people who cook and heat their homes with biomass fuels and coal. An estimated 4.3 million premature deaths were attributable to household air pollution in 2012.

According to the latest urban air quality database (2016), 98% of cities in low- and middle income countries with more than 100 000 inhabitants do not meet WHO air quality guidelines. People living in low- and middle-income countries disproportionately experience the burden of outdoor air pollution with 87% (of the 3 million premature deaths) occurring in low- and middle-income countries, and the greatest burden in the WHO Western Pacific and South-East Asia regions.

Almost 94% of deaths worldwide are due to non-communicable diseases in adults, such as cardiovascular diseases (stroke and heart disease), chronic obstructive pulmonary disease and lung cancers which can be directly attributed to air pollution. It is estimated that the number of deaths because of air pollution will reach 6 million per year by the year 2050. Air pollution and its effect on health is a very complex subject since there are many different pollutants and their individual effects on health are difficult to discern. Ambient air pollution is a global challenge and evidence shows that adverse effects still exist even at relatively low air pollutant concentrations.

Global Trends in Air Pollution

- Global urban air pollution levels increased by 8%, despite improvements in some regions of the world.
- In general, urban air pollution levels were lowest in high-income countries, with lower levels most prevalent in Europe, the Americas, and the Western Pacific Region.
- The highest urban air pollution levels were experienced in low-and middle-income countries in WHO's Eastern Mediterranean and South-East Asia Regions, with annual mean levels often exceeding 5-10 times WHO limits, followed by low-income cities in the Western Pacific Region.

- In the Eastern Mediterranean and South-East Asia Regions and low-income countries in the Western Pacific Region, levels of urban air pollution has increased by more than 5% in more than two-thirds of the cities.
- In the African Region urban air pollution data remains very sparse, however available data revealed particulate matter (PM) levels above the median. The database now contains PM measurements for more than twice as many cities than previous versions.

AIR POLLUTION IN SOUTH ASIA and NEPAL

Urban air pollution in Kathmandu valley is coming up as a serious problem which exceeds both the national and international standards. In Nepal, air in both urban and rural areas is polluted by mainly pollutants emitted from human activities. Rapid urbanization and migration of rural people to urban areas coupled with increasing number of vehicles running in poorly maintained roads, concentration of industries in urban areas, uncontrolled waste management practices are the major source of air pollution in urban areas. In rural areas, the use of solid biomass fuels such as woods, cow-dung, and agriculture residues as source of energy for cooking and heating purposes particularly in the poorly ventilated houses is the main concern of indoor air pollution. The polluted air quality in major cities and indoor air pollution in rural areas is adversely affecting the health of people. Solid bio-fuels are the primary cause of biomass smoke and results in indoor air pollution. This problem is more pronounced in the rural parts of Nepal because they are poor and cannot afford to adopt cleaner fuels. It seems that the poor will continue using bio fuels seeing the tempo of development of our country. Women and children are particularly more exposed to indoor smoke due to limited ventilation and also because women and children spend long periods of time indoors.

A comparative analysis of situation of air pollution as compared with other South Asian countries based on different indicators is presented below:

Indicator 1: Modelled population exposure to particulate matter ($PM_{2.5}$)

Country	Score					
	Urban and Rural PM2.5 [µg/m3]			Urban PM2.5 [µg/m3]		
	Median	Lower	Upper	Median	Lower	Upper
Afghanistan	46	26	80	63	41	98
Bangladesh	84	53	131	89	58	134
Bhutan	48	30	79	39	30	50
India	62	41	95	66	45	97
Maldives	16	8	29	N/A	N/A	N/A
Nepal	**64**	**33**	**123**	**74**	**39**	**140**
Pakistan	60	37	97	68	43	107
Sri Lanka	27	14	51	28	15	55

Indicator 2: Deaths, YLLs(Years of life lost), DALYs (Disability-adjusted life years)attributable to APP (Ambient Air Pollution)

Deaths Attributable to AAP in both sex, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI (Acute Lower Respiratory Disease)	COPD(Chronic Obstructive Pulmonary Disease)	Lung Cancer	IHD (Ischaemic Heart Disease)	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	3772	188	301	3183	3071	11145	896,113,570	37	81
Bangladesh	3850	8316	4375	10291	10617	37449	3,024,546,036	24	38
Bhutan	20	29	14	76	53	192	154,237	26	40
India	39914	110500	26334	249388	195001	621138	515,241,744,416	49	68
Maldives	1	1	3	23	20	48	12,65	14	23
Nepal	**740**	**1770**	**923**	**3328**	**3183**	**9943**	**742,613,057**	**36**	**56**
Pakistan	13683	5688	2394	20772	16705	59241	4,875,771,340	33	52
Sri-Lanka	33	275	365	4846	2273	7792	56,759,843	38	38

Deaths Attributable to AAP in women, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	1798	88	77	1828	1752	5544	44,636,739	38	81
Bangladesh	1728	3729	859	3345	5442	15084	1,207,418,726	20	31
Bhutan	9	11	7	31	29	86	69,105	25	40
India	20455	47210	6202	89727	96383	259977	214,832,312,709	43	57
Maldives	0	1	0	9	5	16	422	9	17
Nepal	**354**	**902**	**438**	**1446**	**1588**	**4728**	**35,056,257**	**33**	**51**
Pakistan	5883	1313	361	9764	9086	26390	2,206,431,251	31	49
Sri-Lanka	13	96	100	1745	961	2915	21,173,689	28	26

Deaths Attributable to AAP in men, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	1974	100	224	1985	1318	5601	44,976,829	37	80
Bangladesh	2121	4587	3516	6946	5915	22365	1,817,527,311	29	45
Bhutan	12	18	7	45	24	106	84,132	27	39
India	19459	63291	20132	159661	98618	361161	300,418,431,873	55	80
Maldives	0	1	3	14	15	32	843	19	29
Nepal	**385**	**869**	**484**	**1882**	**1595**	**5216**	**39,226,802**	**39**	**61**
Pakistan	7800	4375	2032	11008	7637	32852	2,665,940,154	36	56
Sri-Lanka	19	178	266	3101	1312	4877	35,556,154	49	54

YLLs Attributable to AAP to both sex, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	342278	4660	9762	120813	88567	566080	445,478,704,450	1904	2456
Bangladesh	349663	167797	120661	264736	239167	1142024	9,387,271,382,416	763	1007
Bhutan	1854	645	463	2307	1412	6682	54,028,140	898	1195
India	3624190	2516699	805530	7412934	5230651	19590004	1,646,907,123,179,470	1550	1899
Maldives	63	26	96	515	437	1138	2,901,520	330	514
Nepal	**67160**	**37949**	**27843**	**87564**	**75614**	**296130**	**224,082,383,002**	**1077**	**1438**
Pakistan	1242440	115082	70507	534538	382748	2345359	19,236,092,848,577	1322	1518
Sri-Lanka	2981	4972	10032	117189	52962	188138	137,899,235,835	921	839

YLLs Attributable to AAP to women, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	163099	2231	2648	56435	50570	274883	216,653,341,781	1905	2411
Bangladesh	156975	76788	30572	78697	118505	461536	376,188,563,712	601	814
Bhutan	801	254	232	891	782	2952	23,943,597	860	1188
India	1857079	1023759	198706	2306544	2414822	7800910	65,170,749,293,312	1282	1520
Maldives	27	14	16	193	111	362	89,483	210	346
Nepal	**32168**	**19509**	**14486**	**36272**	**37045**	**139481**	**104,679,181,830**	**985**	**1315**
Pakistan	534059	27645	11666	235717	203293	1012379	8,360,441,220,982	1174	1363
Sri-Lanka	1268	1622	2741	35253	19846	60692	4,427,276,426	576	534

YLLs Attributable to AAP to men, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	179179	2492	7115	64378	37997	291097	228,829,362,678	1904	2498
Bangladesh	192688	21010	90088	186039	120662	680488	562,668,818,621	868	1192
Bhutan	1053	391	231	1416	631	3723	30,084,544	932	1206
India	1767111	1492940	606825	5106390	2815829	11789093	994,679,513,893,270	1799	2272
Maldives	36	12	79	322	326	776	2,001,038	449	680
Nepal	**34992**	**18440**	**13357**	**51291**	**38569**	**156649**	**119,368,201,233**	**1174**	**1566**
Pakistan	708381	87437	58841	298866	179455	1332980	10,870,991,627,624	1462	1665
Sri-Lanka	1773	3328	2395	31556	47697	235036	128,740,357,480	1280	1312

DALY Attributable to AAP to both men and women, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	343358	9245	9915	121757	88934	573208	450,258,714,931	1298	2501
Bangladesh	353835	271662	121865	270583	249310	1267255	10,199,711,565,478	816	1114
Bhutan	1876	1005	465	2333	1452	7132	56,798,840	959	1274
India	3663274	3282841	813674	7455375	5290815	20506014	1,704,620,424,531,620	1623	1968
Maldives	66	54	96	521	457	1194	3,001,623	346	537
Nepal	**68013**	**53739**	**27934**	**88479**	**77065**	**315230**	**234,391,415,553**	**1146**	**1533**
Pakistan	1246970	203138	71703	540886	390112	2452808	19,929,563,003,450	1383	1605
Sri-Lanka	3132	9962	10083	118065	54977	196219	141,976,249,981	961	931

DALY Attributable to AAP to women, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	163611	4545	2696	56907	50706	278465	2,189,793,468,868	1929	2456
Bangladesh	158982	124061	30763	81010	122603	517418	411,938,645,789	673	910
Bhutan	812	379	232	900	795	3137	25,043,873	911	1260
India	1875402	1385368	200791	2324770	2441642	8227991	67,916,299,916,369	1352	1603
Maldives	28	28	16	196	121	390	94,535	227	369
Nepal	**32578**	**27385**	**14513**	**36702**	**37666**	**148843**	**109,737,197,727**	**1052**	**1403**
Pakistan	536188	64594	11813	238540	206188	1057323	8,658,951,286,013	1226	1438
Sri-Lanka	1281	4155	2756	35646	20868	64706	4,627,483,474	614	596

DALY Attributable to AAP to men, by disease and country

Country	Number of Deaths							Deaths per 100 000 capita	
	ALRI	COPD	Lung Cancer	IHD	Stroke	Total	Uncertainty Interval	Crude Rate	Age-standardized Rate
Afghanistan	179747	4700	7219	64849	38228	294743	231,285,368,064	1928	2543
Bangladesh	194853	147601	91102	189574	126707	749837	607,961,919,646	956	1309
Bhutan	1064	608	233	1433	657	3995	31,754,967	1000	1292
India	1787871	1897456	612883	5130605	2849209	12278024	1,026,216,614,606,630	1874	2363
Maldives	38	25	80	325	336	804	2,051,088	465	703
Nepal	**35435**	**26354**	**13412**	**51778**	**39398**	**166387**	**124,723,217,702**	**1247**	**1666**
Pakistan	710781	138543	59890	302346	183925	1395486	11,271,211,716,701	1531	1765
Sri-Lanka	1851	5807	7326	82420	34109	131513	95,676,166,551	1330	1354

COMMON AIR POLLUTANTS

The most common air pollutants are:

1. **Ozone:** Ozone is created at ground level by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Depending on its location in the atmosphere, ozone can be 'good' or 'bad. Good ozone occurs naturally in the stratosphere, 10 to 30 miles above the surface of the earth and it forms a layer that protects life on earth from the powerful rays of the sun. 'Bad' ozone contains motor vehicle exhaust, industrial emissions, chemical solvents and other hazardous substances, forming the bulk of the clouds of smog that form over many urban areas.
2. **Particulate Matter:** Particulate matter is a mixture of both tiny solid particles and liquid droplets made up of any number of potentially hazardous components including acids, organic chemicals and toxic metals as well as soil or dust particles. Particulate matter falls into two categories: Inhalable coarse particles and fine particles. Inhalable coarse particles are between 2.5 micrometers and 10 micrometers in diameter. They are found near roadways and dusty industries. Whereas, fine particles are 2.5 micrometers or smaller and are emitted during forest fires, and can also form when gases emitted by power plants, factories and automobiles react in the air. Both categories can pass through the throat and nose and enter the lungs.
3. **Carbon Monoxide**: Carbon monoxide (CO) is an odorless, colorless, non-irritating but very poisonous gas emitted from combustion processes that can reduce oxygen delivery into the body's tissues and organs, including the heart and brain, when inhaled. At high levels, carbon monoxide can cause death. Most carbon monoxide emissions in ambient air come from mobile sources.
4. **Nitrogen Oxides**: The group of highly reactive gases known as nitrogen oxides (NOx) is emitted by high-temperature combustion and often appears as a brown dome of haze over cities. Of the group of nitrogen oxides, which also includes nitrous acid and nitric acid, nitrogen dioxide (NO2) is of the greatest concern to the environment protection agencies. It contributes to the formation of ground-level ozone and fine particle pollution, and is linked to adverse effects on the human respiratory system.
5. **Sulfur Dioxide:** Sulfur dioxide (SO2) is a chemical compound produced by volcanic eruptions and industrial processes. The largest sources of sulfur dioxide emissions are from fossil fuel combustion at power plants. In the presence of a catalyst like nitrogen dioxide, sulfur dioxide can oxidize into acid rain. It, too, is linked to many adverse health effects on the respiratory system.

WHY CONTROL AIR POLLUTION?

Clean air is considered to be a basic requirement of human health and well-being. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. Air pollution affects respiratory system causing breathing difficulties and severe diseases and also affects the central nervous system causing carbon monoxide poisoning. The lower the levels of air pollution, the better the cardiovascular and respiratory health of the population will be, both long- and short-term.

Reducing outdoor emissions from household coal and biomass energy systems, agricultural waste incineration, forest fires and certain agro-forestry activities (e.g. charcoal production) would reduce key rural and urban air pollution sources in developing regions. Reducing outdoor air pollution also reduces emissions of carbon dioxide and short-lived climate pollutants such as black carbon particles and methane, thus contributing to the near- and long-term mitigation of climate change.

Air pollution is known to do serious damage to the health of people. Air pollution causes depletion of ozone layer due to which ultraviolet radiations can reach the earth and cause skin cancer, damage to eyes and immune system. It is also known to cause acid rain. It causes greenhouse effect or global warming which leads to excessive heating of earth's atmosphere, further leading to weather variability and rise in sea level. The increased temperature may cause melting of ice caps and glaciers, resulting in floods. Air pollution from certain metals, pesticides and fungicides causes serious illnesses. All these factors make it vital to control air pollution. When air quality improves, health costs from air pollution-related diseases shrink, worker productivity expands and life expectancy grows.

RECOMMENDATIONS

Policies and investments supporting cleaner transport, energy-efficient housing, power generation, industry and better municipal waste management would reduce key sources of urban outdoor air pollution. Policies are required to address air pollution which may generate a number of benefits to human health, not only through air quality improvements but also other health benefits, such as injury prevention or enabling physical activity. It is more important in Asian developing countries due to the severe pollution levels and high population densities associated with them. Improving air quality has substantial, measurable and important public health benefits. Efforts should be made and goals set in order to control air pollution in every country. Reducing industrial smoke emissions, increasing use of renewable power sources, like solar and wind, and prioritizing rapid transit, walking and cycling networks in cities are among the

suite of available and affordable strategies. It is crucial for city and national governments to make urban air quality a health and development priority. Controlling unsustainable pollution levels requires a technological and an intellectual revolution; an alternative route to economic prosperity that preserves resources and limits carbon emissions has to be developed before it's too late. Reliable estimates of exposure to air pollutants and related impacts on health are key to better inform policy-makers, as well as other health and development partners. Such information is essential to implementing, monitoring and evaluating policies that help to tackle air pollution meanwhile also protecting health.