Indoor Air Pollution

Data Analysis and Visualization using Python

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Acknowledgement

I would like to express my sincere gratitude to my supervisor Dr Sharanjeet Kaur for providing their invaluable guidance, comments and suggestions throughout the course of the project. I would specially thank Dr Sharanjeet Kaur for constantly motivating me to work harder. It is privileged to acknowledge my deepest gratitude to her for her unstilted support and encouragement in the preparation of this project.

Datasets used in this project

- Access to clean fuels vs various factors:
  https://datacatalog.worldbank.org/search/dataset/0037712
  http://ghdx.healthdata.org/gbd-results-tool
  http://data.worldbank.org/data-catalog/world-development-indicators

- Death Rates data:
  http://ghdx.healthdata.org/gbd-results-tool
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  http://ghdx.healthdata.org/gbd-results-tool

- Death rates and reasons, across the world:
  https://unstats.un.org/unsd/demographic/products/Worldswomen/WW2010%20Report_by%20chapter(pdf)/Environment.pdf
  https://ehp.niehs.nih.gov/1205987/
  http://ghdx.healthdata.org/gbd-results-tool
  http://data.worldbank.org/data-catalog/world-development-indicators
  http://ghdx.healthdata.org/gbd-results-tool

- https://ourworldindata.org/indoor-air-pollution

Data Description

Access to clean fuels and technologies for cooking is the proportion of the total population primarily using clean cooking fuels and technologies for cooking. Under WHO guidelines, kerosene is excluded from clean cooking fuels.

Statistical concept and methodology: Data for access to clean fuels and technologies for cooking are based on the the World Health Organization's (WHO) Global Household Energy Database. They are collected among different sources: only data from nationally representative household surveys (including national censuses) were used. Survey sources include Demographic and Health Surveys (DHS) and Living Standards Measurement Surveys (LSMS), Multi-Indicator Cluster Surveys (MICS), the World Health Survey (WHS), other nationally developed and implemented surveys, and various government agencies. To develop the historical evolution of clean fuels and technology use rates, a multi-level non-parametrical mixed model, using both fixed and random effects, was used to derive polluting fuel use estimates for 150 countries (ref. Bonjour S, Adair-Rohani H, Wolf J, Bruce NG, Mehta S, Prüss-Ustün A, Lahiff M, Rehfuess EA, Mishra V, Smith KR. Solid Fuel Use for Household Cooking: Country and Regional Estimates for 1980-2010. Environ Health Perspect (): .doi:10.1289/ehp.1205987.). For a country with no data, estimates are derived by using regional trends or assumed to be universal access if a country is classified as developed by the United Nations.

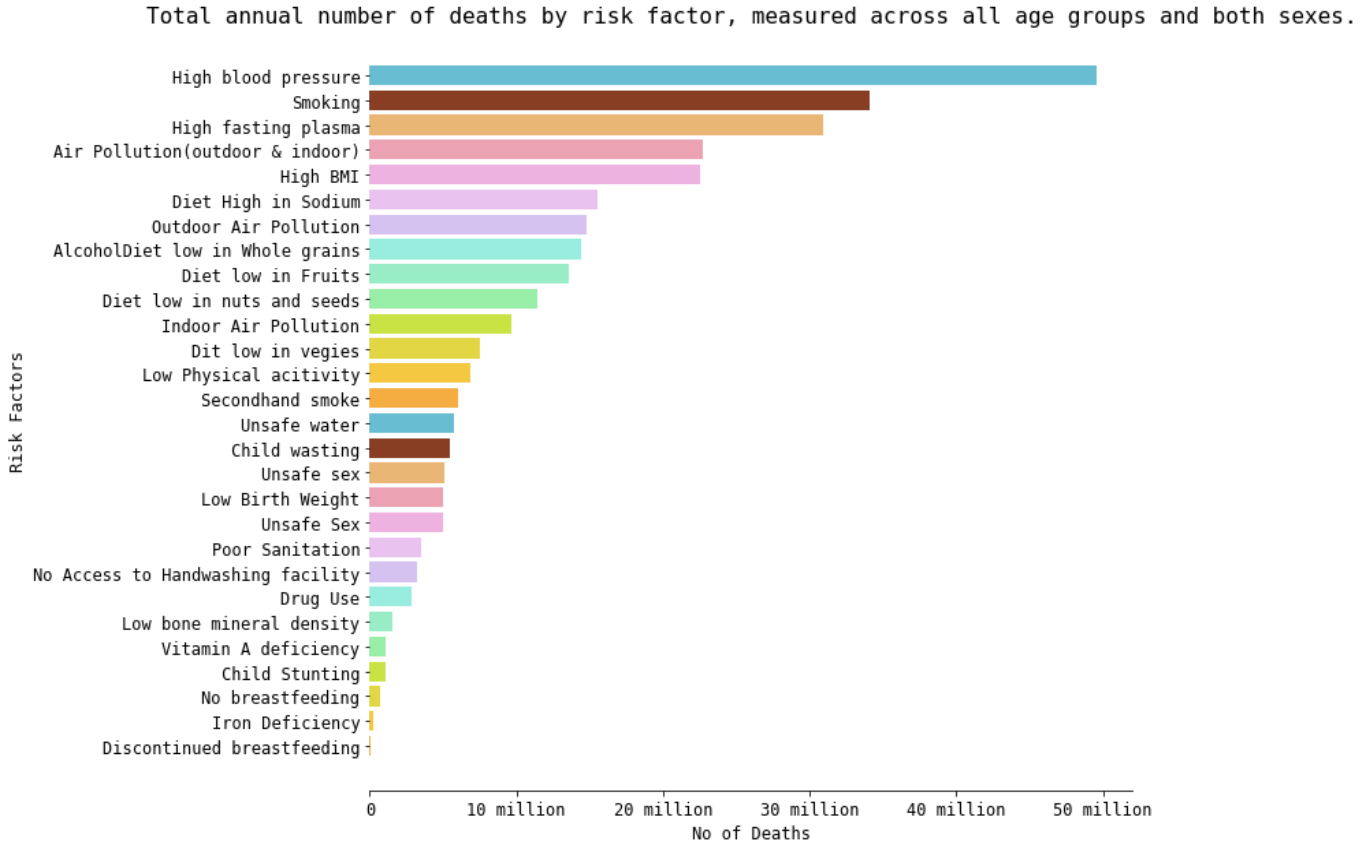
GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the country plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.
Data are in constant 2017 international dollars.
Countries are grouped by WHO region and income category (WHO 2012

Most of the data has been published by

United Nation Publications
Institute for Health Metrics and Evaluation (IHME)
World Development Indicators - World Bank

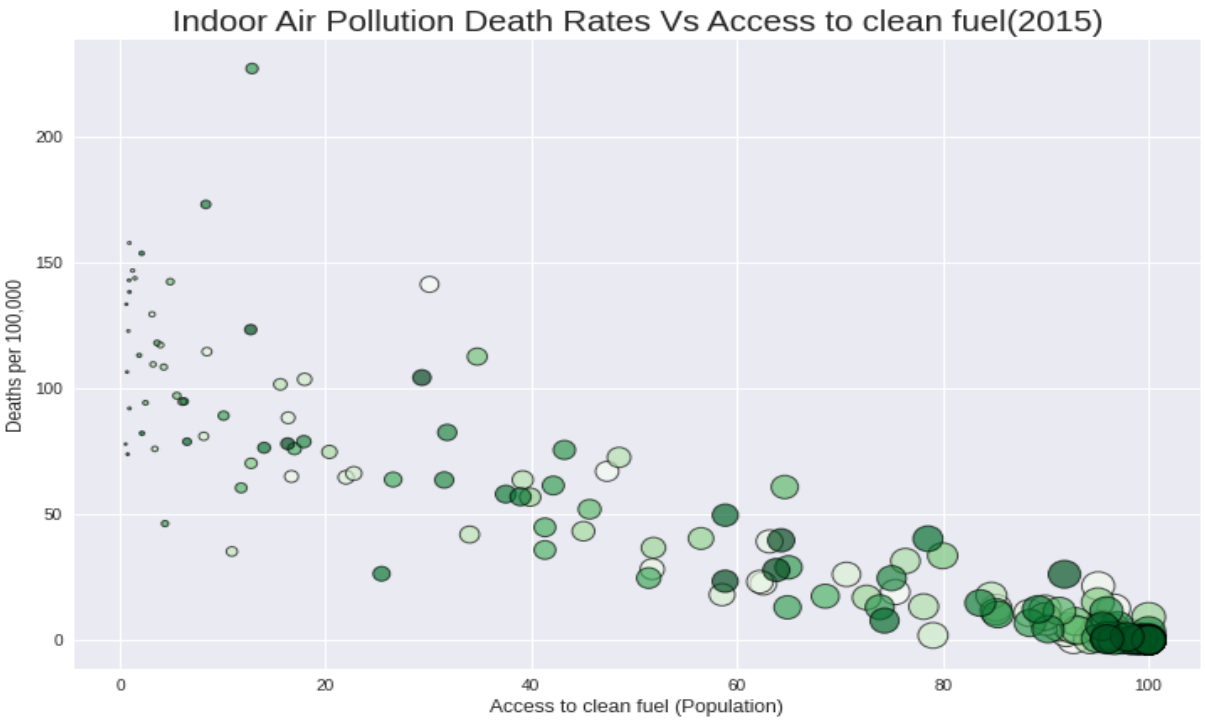
Indoor Air Pollution is one of the leading risk factors for premature deaths

Indoor air pollution is one of the leading risk factors mostly in poor countries. Countries where people heavily rely on solid fuels such as crop waste, cow dung or charcoal for cooking and other purposes see more premature deaths than any developed country or a country where people have access to clean cooking fuels and technologies.
The estimates of the annual number of deaths attributed to a wide range of risk factors are shown below in the graph.



Indoor air pollution arises from the burning of a solid fuel which suffocates the environment and causes illness in people. People who cant afford clean fuels and the latest technologies for cooking and heating purposes tend to suffer more from respiratory diseases and die prematurely as compared to those who have cleaner fuels.

In the visualization below a very strong connection has been found out between the number of deaths from indoor air pollution and the percentage of the population with access to clean fuels.



As can be seen in the visualization above population which have 100% access to clean fuels and technologies for cooking tend to die less from indoor air pollution.
The difference in deaths between people with no or little access to cleaner fuels and the one with cleaner fuels is drastic.

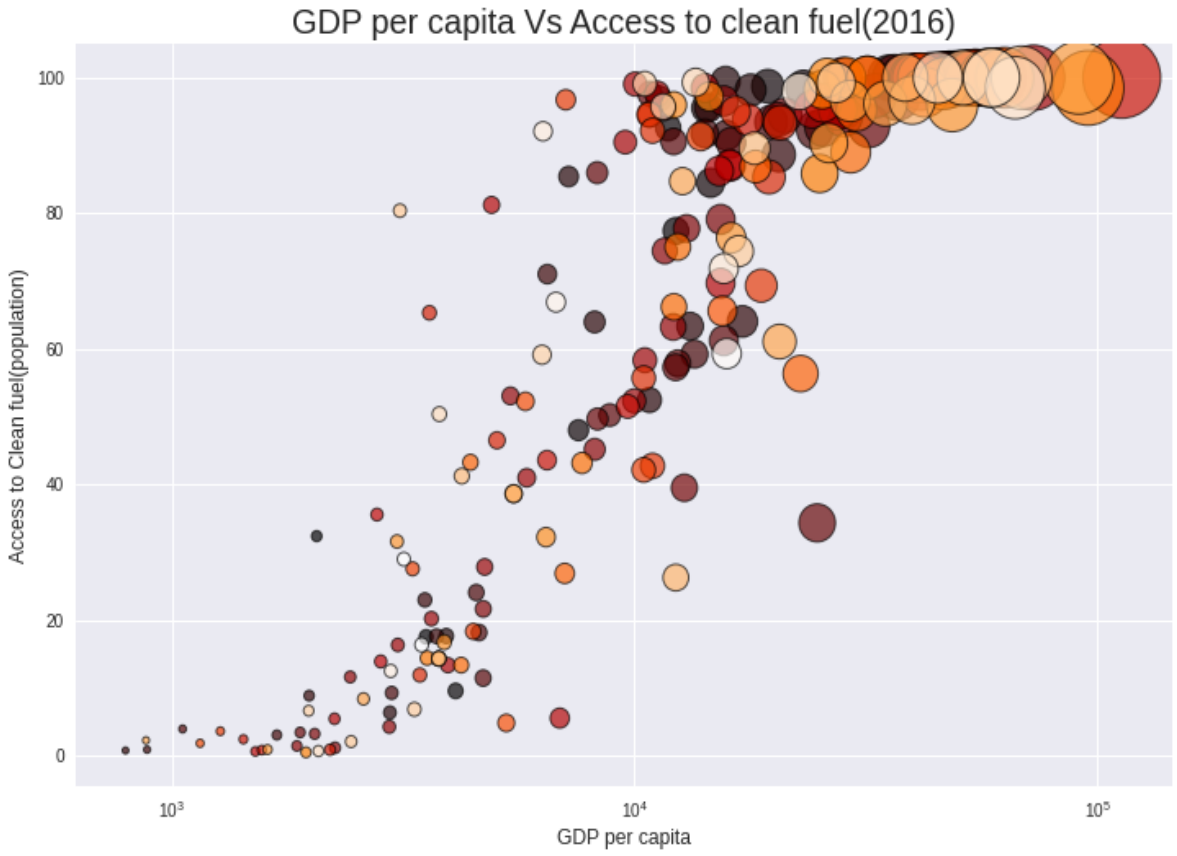
Poorer households have a higher dependence on solid fuels

Poorer households heavily depend on solid fuels and their death rates due to respiratory diseases are drastic, there can be many factors behind their dependence for example the one we encountered above in the visualization is not having access to clean fuels and technologies for cooking.

Income is a strong determinant of energy access and types of fuel sources. At low-income levels, households mostly rely on traditional cooking fuels, as the income rises they switch to charcoal and coal which is still not a better option, Only at higher income levels do households shift from harmful solid fuels to cleaner non-solid fuels such as ethanol and natural gas. Electricity is only available for households at a high-income level.

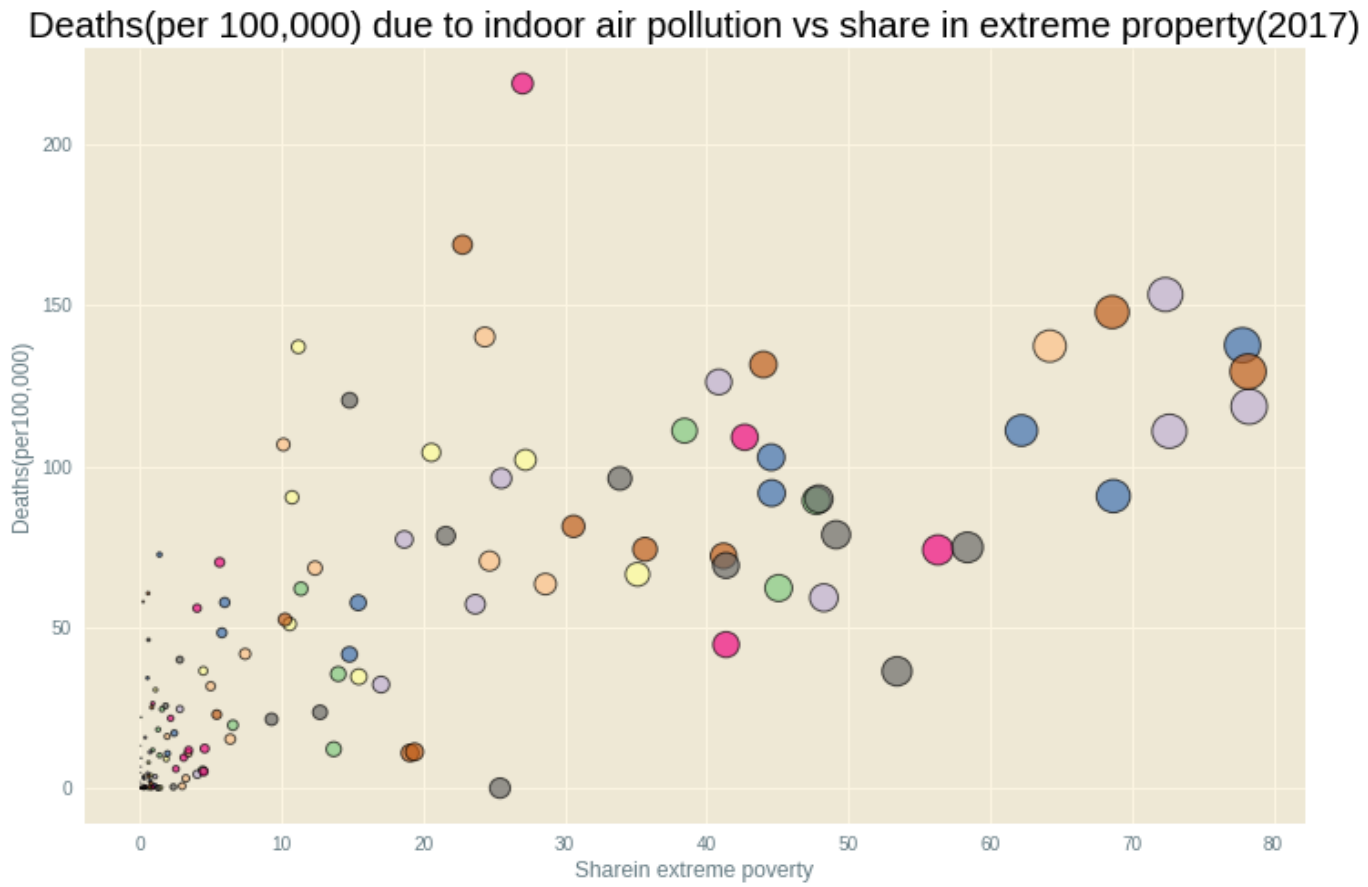
In the scatterplot below a correlation between the percentage of the population with access to cleaner fuels(for various countries all over the world) and their GDP per capita(in $) is established.

For countries where GDP per capita remains low, their access to clean fuels is also low. As countries begin to bridge that gap between low and middle incomes, this share begins to increase until a final transition towards high-income where the majority of households have clean fuels and technologies for cooking.



Let us look at one more visualisation which directly tells us how the countries where a large part of the population lives under extreme poverty faces more deaths(per 100,000) as compared to those countries where only a small population lives under extreme poverty.

In the scatterplot visualization below it can be seen quite clearly how the number of



deaths rises as the population living in extreme poverty increases.

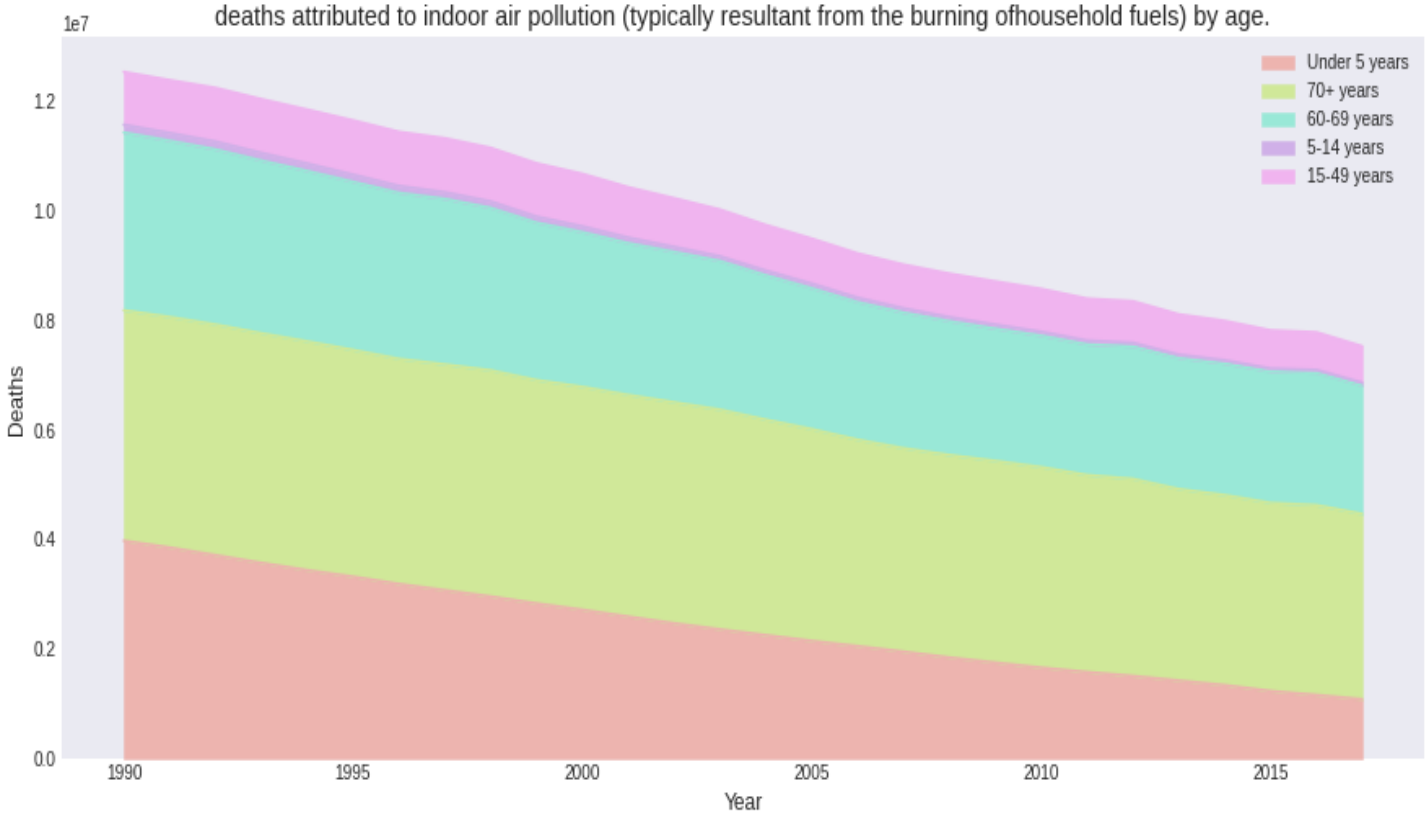
With all these visualisations it is clear that the countries living in extreme poverty or where the GDP per capita is low encounter more deaths due to indoor air pollution as they don't have access to clean fuels

Countries where more than 50% of the population living under extreme poverty are Burundi, Central African Republic, Democratic Republic of Congo, Guinea-Bissau, Madagascar, Malawi, Mozambique, Rwanda, Somalia, South Sudan, Yemen, Zambia

In the year 2017, in India, more than 14cr people were living in extreme poverty, which is 10.55% of the total population.

Deaths by Age

In 2017, 1.6 million people died prematurely as a result of indoor air pollution – 45% were aged 70 and older. This visualization shows the breakdown of deaths by age group.

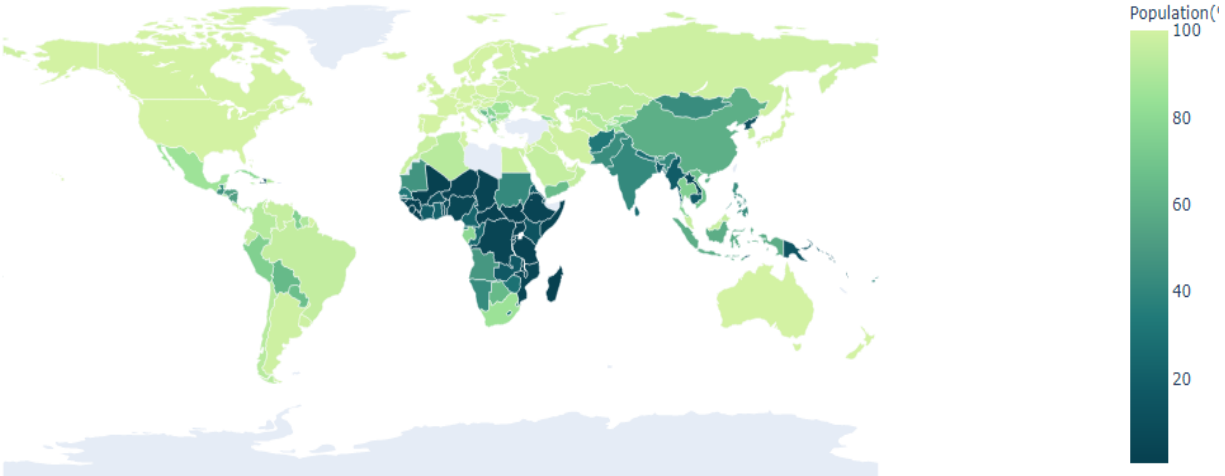


Access to clean fuels for cooking

Clean fuels' are defined by emission rate targets and recommendations for and against particular fuel use in the World Health Organization's guidelines for indoor air quality: household fuel combustion.6 The WHO recommends against the use of solid fuels, unprocessed coal and kerosene for indoor cooking since these fuels exceed its emission rate targets. The 'clean fuels' is recommended include biogas, ethanol, LPG, natural gas and electricity. Solar cookstoves can also be an important solution where conditions are suitable

The map below shows the percentage of households with access to clean fuels and technologies for cooking

Share of population with Access to Clean Fuel and Technologies for cooking, 2016



Access is lowest across Sub-Saharan Africa where only 14% of households in 2016 had

access. Progress has been much more significant in South Asia and East Asia over the last decade, with 18 per cent and 16% of additional households gaining access, respectively.

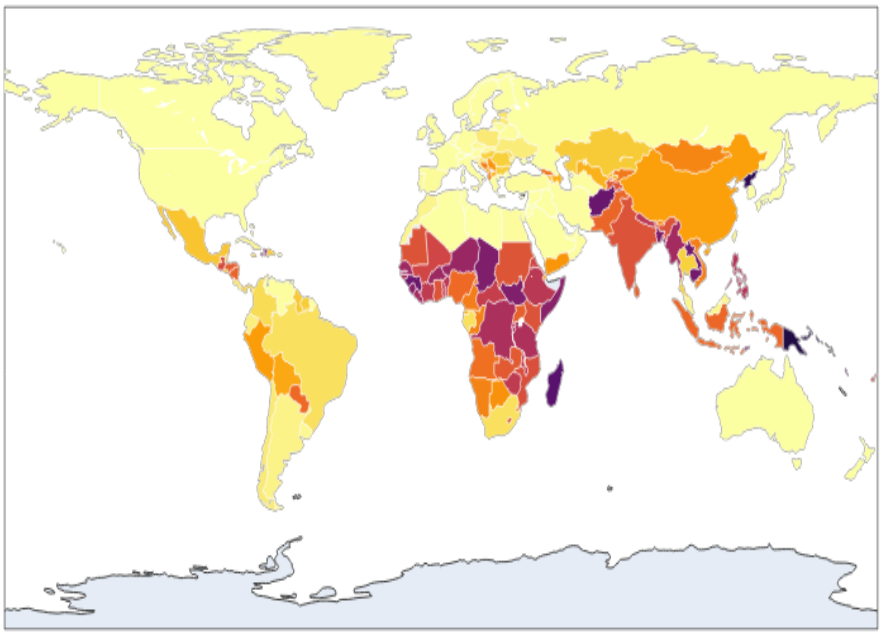
The Global Distribution of Deaths from Indoor Air Pollution

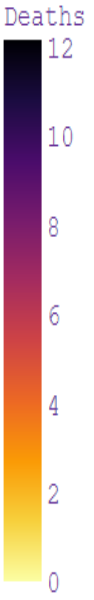
In the map below the share of premature deaths attributed to indoor air pollution have been depicted. In the map here we see the share of annual deaths attributed to indoor air pollution across the world. In 2017 this ranged from a high of close to 11% in Papua New Guinea – more than 1-in-10 deaths – to less than 0.1% across most of Europe and North America.

Developed countries where GDP per capita is higher, encounter fewer deaths attributed to indoor air pollution like Austria, Germany, or North America.

In North Korea, Oceania, Papua New Guinea, and the Solomon Islands more than 10% of the deaths are attributed to indoor air pollution.

Share of deaths from indoor air pollution, 2017





Death rates are highest across low-income countries

Death rates from indoor air pollution give us an accurate comparison of differences in its mortality impacts between countries and overtime

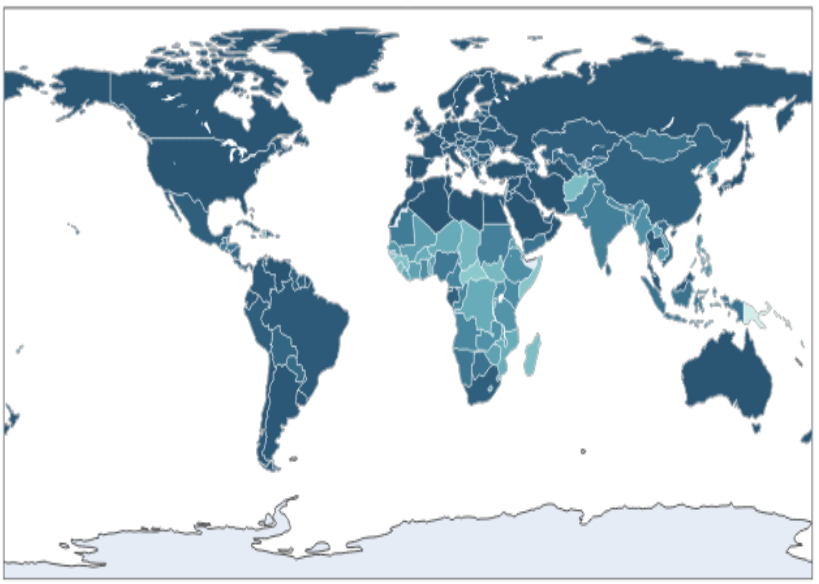
In the map below we see death rates from indoor air pollution across the world. Death rates measure the number of deaths per 100,000 people in a given country or region.

What becomes clear is the large differences in death rates between countries: rates are high in lower-income countries, particularly across Sub-Saharan Africa and Asia. Rates here are often greater than 100 deaths per 100,000 – in Papua New Guinea this was over 200 per 100,000.

Compare this with death rates across high-income countries: across North America rates are below 0.1 deaths per 100,000. That's a greater than 1000-fold difference.

The issue of indoor air pollution, therefore, has a clear economic split: it is a problem that has almost been entirely eliminated across high-income countries but remains a large environmental and health problem at lower incomes.

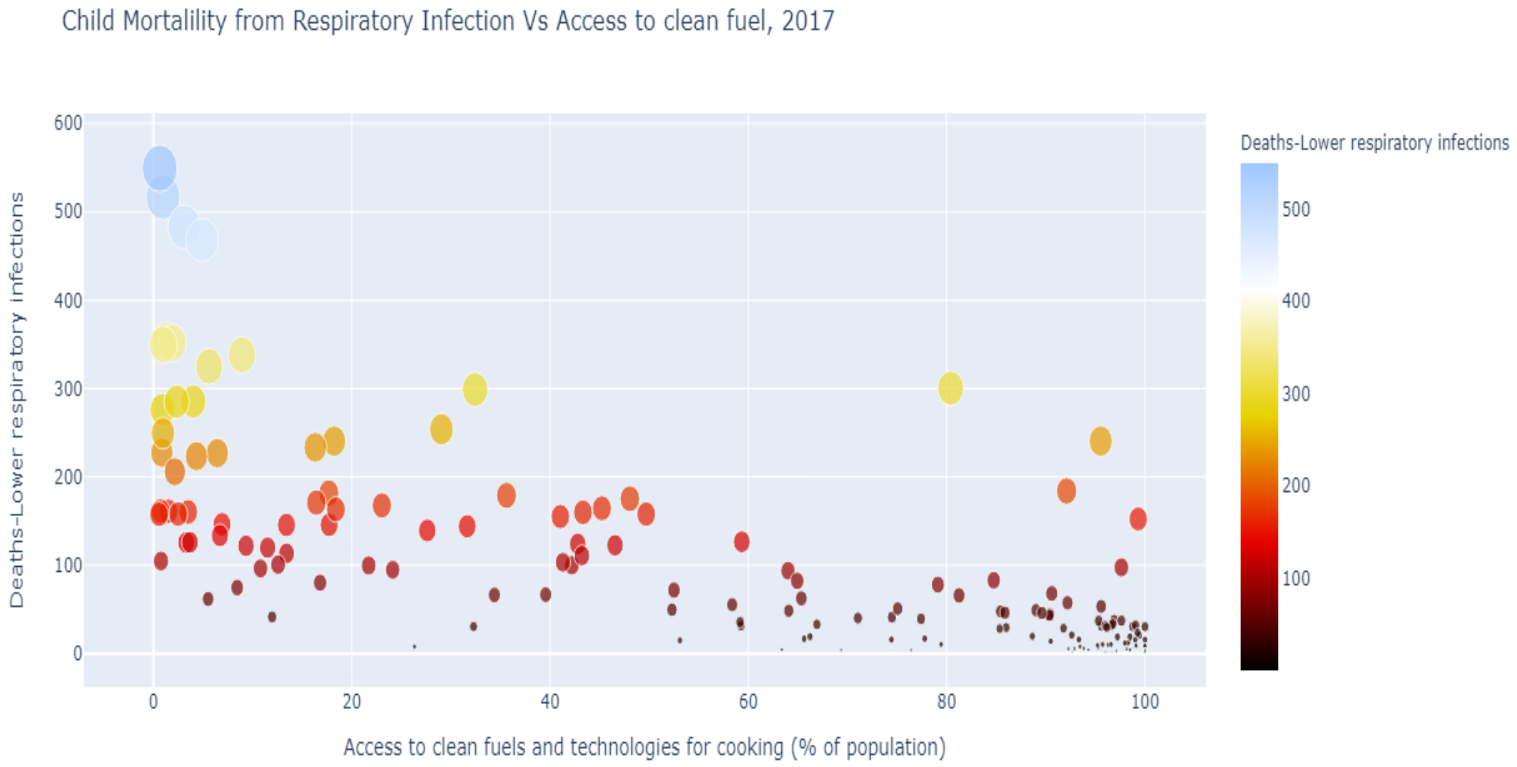
Deaths(per 100,000) from indoor air pollution, 2017



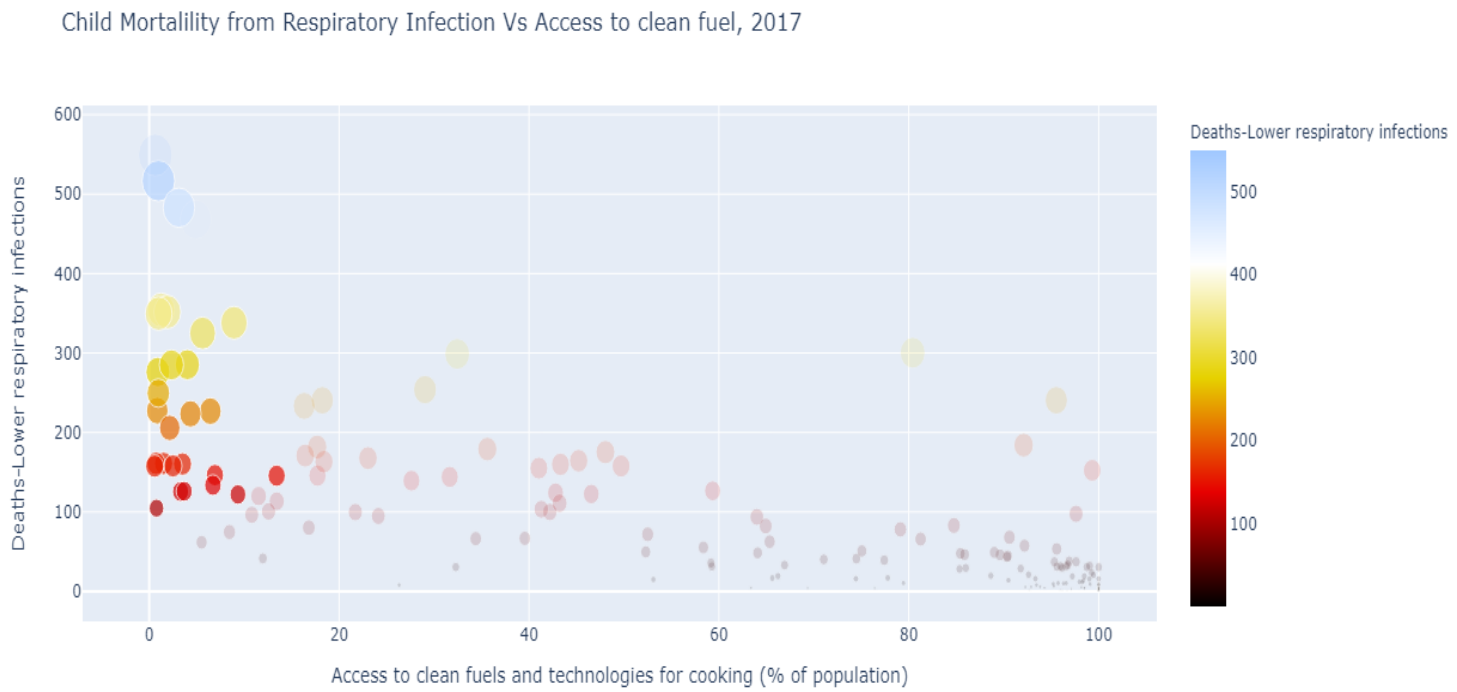
Child Mortality from respiratory infections VS access to clean fuel

The mortality rate of children under five years old from lower respiratory infections, measured as the number of deaths per 100,000. This is shown against the share of the population with access to clean fuels for cooking and heating. Lack of access to clean fuels results in high levels of indoor air pollution – a key risk factor for respiratory infections.

The visualization below shows the child mortality(y-axis) vs the percentage of the population with access to clean cooking fuels and technology for cooking(x-axis)



As can be seen in the below visualization in the countries/regions with access to clean fuels less than 20% no of deaths from respiratory illness is higher



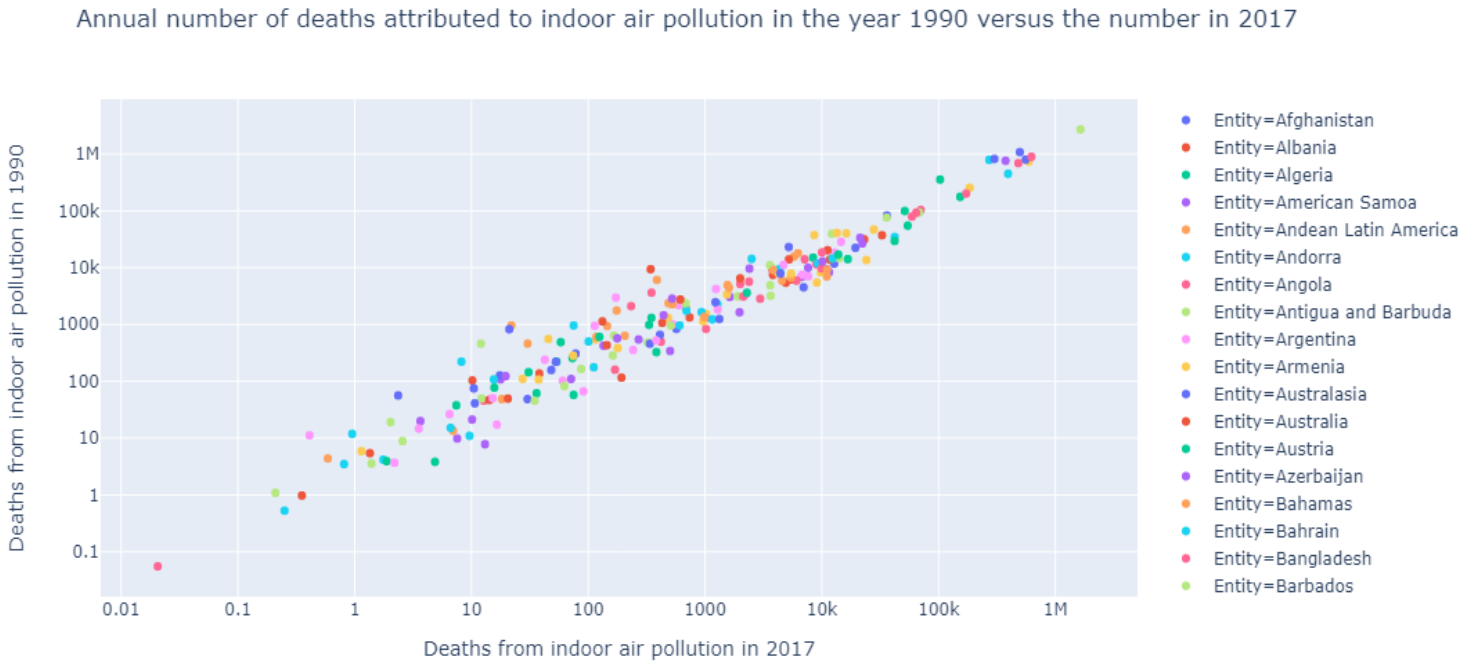
In countries like Sudan, Nigeria, Central African Republic, Chad the child mortality rate is the highest and percentage of the population having access to clean fuels is lower.

How has mortality from indoor air pollution changed over time?

Whilst indoor air pollution is still one of the leading risk factors for mortality, and the largest risk factor at low incomes, the world has also made significant progress in recent decades.

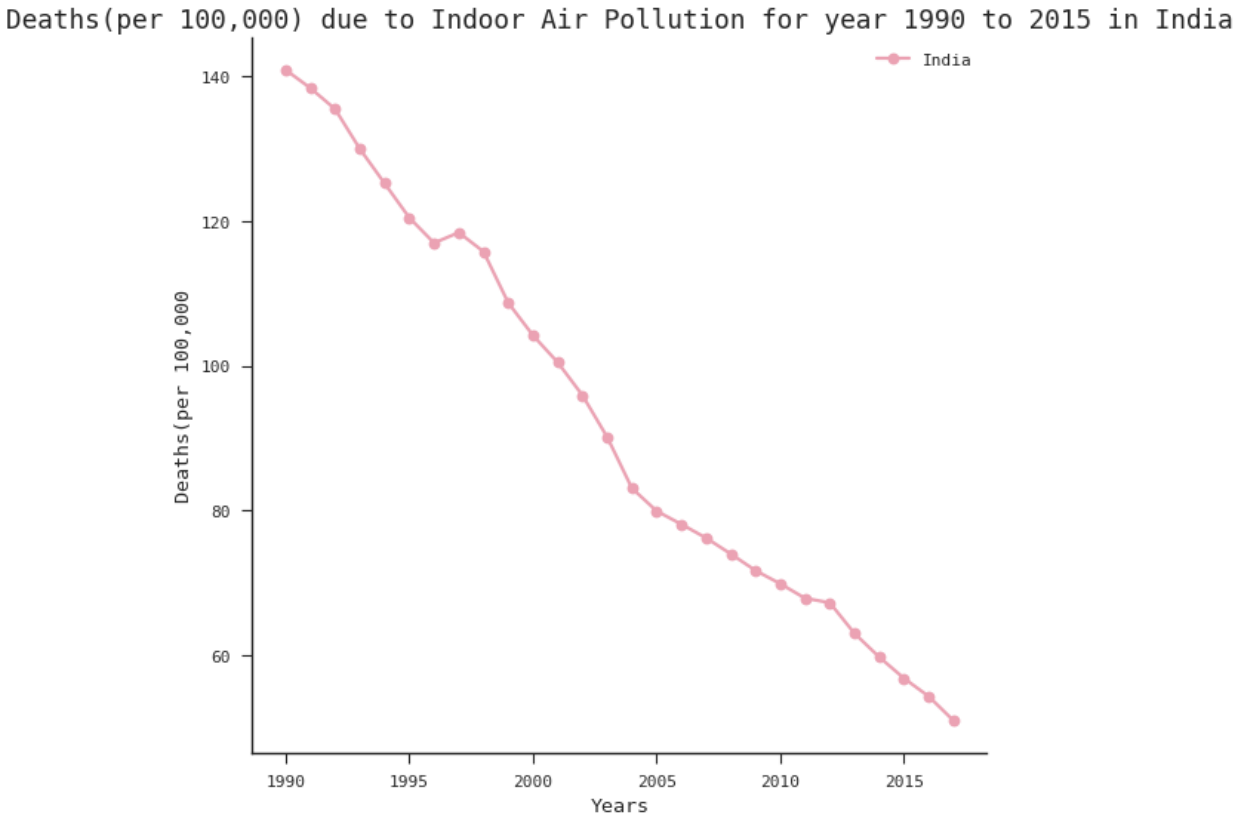
Globally, the number of annual deaths from indoor air pollution has fallen by more than 1 million since 1990.

This means that despite continued population growth in recent decades, the total number of deaths from indoor air pollution has still declined

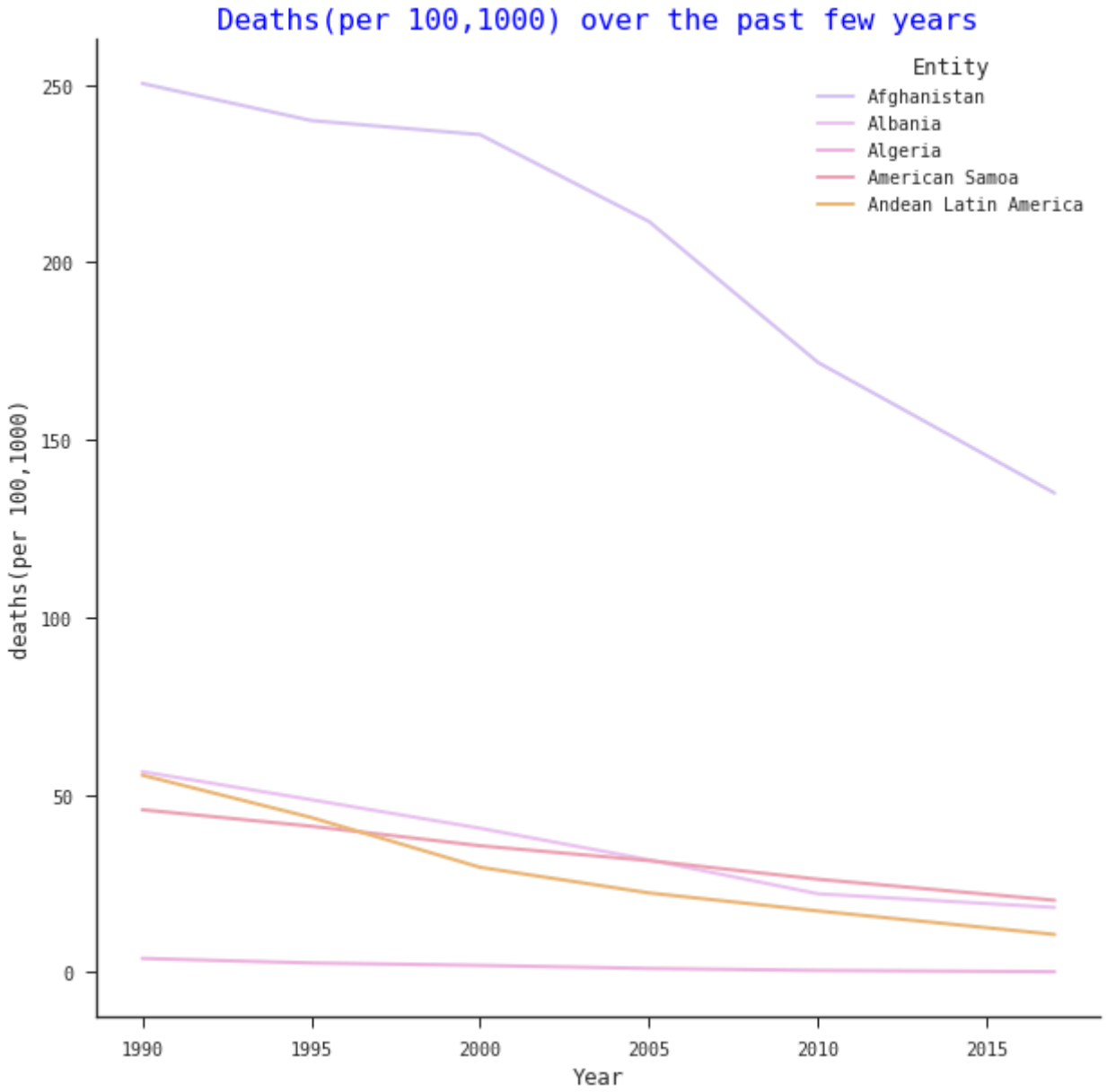


If we compare the deaths over the past few years in India, we see a gradual decline in the

number of deaths(per 100,000)



Countries like Afghanistan, Albania, Algeria, American Samoa and Andean Latin America have also seen a decline in the number of deaths over the past few years.



The cases have declined surely but solid fuels could not be eradicated completely. There are still many countries where a large population heavily relies on solid fuel like cow

dung, charcoal etc for cooking and heating.

The burning of solid fuels fills the houses and huts in poorer countries with smoke that kills the world's poor by causing pneumonia, stroke, heart disease, chronic obstructive pulmonary disease, and lung cancer. The solid fuels responsible for this include wood, crop residues, dung, charcoal, and coal. The solution for this problem is straightforward: shift from solid fuels to modern energy sources.

The chart shows that the world is making progress in this direction. The chart also shows that it is a problem associated with poverty: In richer Europe and North America the share is much lower than in the rest of the world; in the high-income countries of the world the use of solid fuels is entirely a thing of the past.

The use of solid fuels is going down in all of the world's regions.

SDG Target on clean cooking fuel

the UN Sustainable Development Goals (SDGs) is to ensure universal access to affordable, reliable and modern energy services. Here, this is shown as the share of the population with access to clean fuels for cooking and heating.

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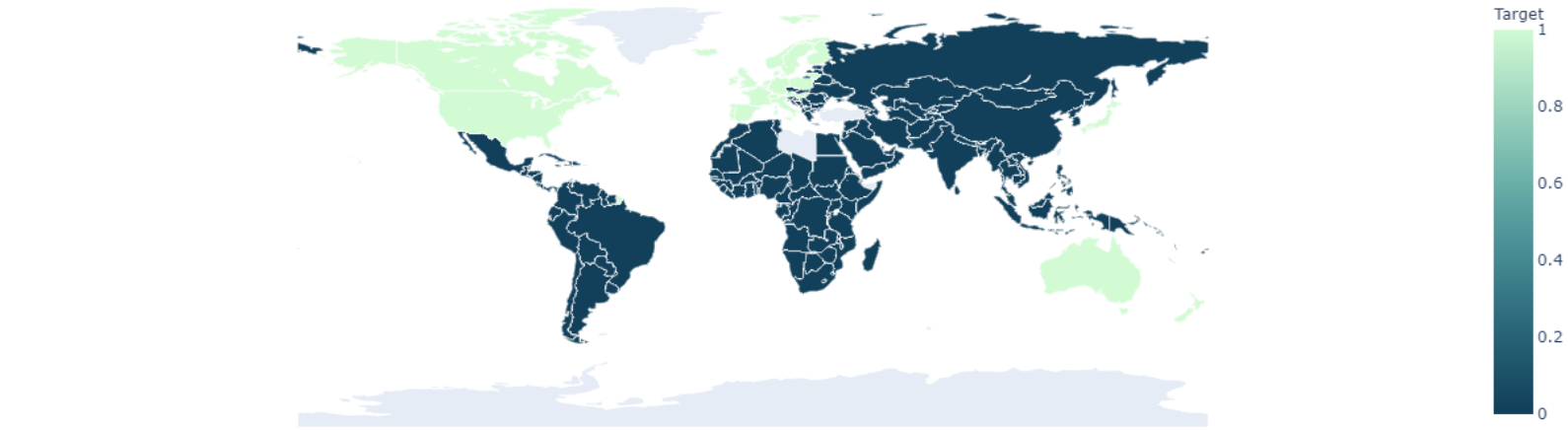

How to make progress against indoor air pollution?

Indoor air pollution results from poor access to clean cooking fuels

Low-income households tend to rely on solid fuels for cooking because cleaner fuels are either unavailable or too expensive. We, therefore, see a strong link between death rates from indoor air pollution and access to clean fuels for cooking. As the access to clean fuels and technologies increases, death rates from household air pollution begin and continue to fall.

Poorer households have a higher dependence on solid fuels

At low-income levels, households rely mostly on solid traditional fuel sources such as crop waste, dung, and firewood. As incomes rise, this energy mix tends to transition towards charcoal and coal. Only at higher income levels do households shift from harmful solid fuels to cleaner non-solid fuels such as ethanol and natural gas. Electricity is only available for households at a high-income level.

Access to clean fuels for cooking

‘Clean fuels’ are defined by emission rate targets and recommendations for and against particular fuel use in the World Health Organization’s guidelines for indoor air quality: household fuel combustion.6 The WHO recommends against the use of solid fuels, unprocessed coal and kerosene for indoor cooking since these fuels exceed its emission rate targets. The ‘clean fuels’ is recommended include biogas, ethanol, LPG, natural gas and electricity. Solar cookstoves can also be an important solution where conditions are suitable.

The obvious way to avoid indoor air pollution from solid fuel burning is for households to transition from traditional ways of cooking and heating towards more modern, cleaner methods. This can, for example, be in the form of transitioning towards non-solid fuels such as natural gas, ethanol or even electric technologies.

Code and DAV concepts used

https://colab.research.google.com/drive/1RKVzQ1x6O2gvYfmVNq5aWyF2QhlHPNTQ?usp=sharing