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ORIGINAL

Analysing the Effects of Environmental Changes on Public Health Quality Indicators

Análisis de los efectos de los cambios ambientales en los indicadores de calidad de la salud pública

Gourab Arun[1] 🔟, Sharmishtha K. Garud[2] 🔟, Chetan Kumar Sharma[3] 🔟

[1]IMS and SUM Hospital, Siksha 'O' Anusandhan (Deemed to be University), Department of General Medicine. Bhubaneswar, Odisha, India.
[2]Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth "Deemed to be University", Dept. of Preventive & Social Medicine. Taluka-Karad, Dist-Satara, Maharashtra, India.
[4]School of Sciences, Noida International University. Greater Noida, Uttar Pradesh, India.

ABSTRACT

As global changes in the environment continue to shape communities, the link between changes in the environment and public health has become clearer. The many ways that changes in the environment can affect public health quality measures are looked at in this study. Air quality, water supply, urbanisation, and climate change are given special attention. As cities grow and more factories are built, the environment changes in ways that make health problems like lung diseases, water-borne diseases, and vector-borne diseases worse. Extreme weather events like storms, floods, and heat waves have also grown to be major determinant of public health. This study examines a lot of studies already conducted to ascertain how environmental changes could result in lower health measurements like life expectancy, mortality rates, and chronic illness prevalence. Furthermore emphasised in the study is the need of knowing how interdependent socioeconomic determinants of health are with external elements as these elements may make vulnerable populations even more vulnerable. The study reveals how environmentally friendly behaviour, modern technology, and government regulations could assist to mitigate the negative health consequences of environmental changes. It also looks at how environmental health tracking systems and predictive analytics can help shape public health policies and make sure that the right steps are taken at the right time. The study shows how careful environmental management and health policy can make public health systems more resilient by looking at global case studies and past data. The results show that to successfully deal with the problems caused by changes in the environment, we need to use interdisciplinary methods that take into account things like hospital infrastructure, environmental sustainability, and community resilience. To sum up, this study makes a strong case for making environmental health a central part of public health policy in order to improve people's quality of life, lower the number of diseases, and achieve long-lasting public health results in the face of ongoing environmental problems.

Keywords: Environmental Changes; Public Health; Quality Indicators; Climate Change; Health Policy.

RESUMEN

A medida que los cambios globales en el medio ambiente siguen moldeando las comunidades, la relación entre los cambios en el medio ambiente y la salud pública se ha hecho más clara. En este estudio se examinan las múltiples formas en que los cambios en el medio ambiente pueden afectar a las medidas de calidad de la salud pública. Se presta especial atención a la calidad del aire, el suministro de agua, la urbanización y el cambio climático. A medida que crecen las ciudades y se construyen más fábricas, el medio ambiente cambia de forma que empeoran problemas de salud como las enfermedades pulmonares, las transmitidas por el agua y las transmitidas por vectores. Los fenómenos meteorológicos extremos, como tormentas, inundaciones

y olas de calor, también se han convertido en importantes determinantes de la salud pública. Este estudio examina muchos estudios ya realizados para determinar cómo los cambios medioambientales podrían dar lugar a una disminución de medidas sanitarias como la esperanza de vida, las tasas de mortalidad y la prevalencia de enfermedades crónicas. Además, el estudio hace hincapié en la necesidad de conocer la interdependencia de los determinantes socioeconómicos de la salud con elementos externos, ya que estos elementos pueden hacer aún más vulnerables a las poblaciones vulnerables. El estudio revela cómo el comportamiento respetuoso con el medio ambiente, la tecnología moderna y la normativa gubernamental podrían ayudar a mitigar las consecuencias negativas para la salud de los cambios medioambientales. También examina cómo los sistemas de seguimiento de la salud ambiental y los análisis predictivos pueden ayudar a configurar las políticas de salud pública y garantizar que se tomen las medidas adecuadas en el momento oportuno. El estudio muestra cómo una gestión medioambiental y una política sanitaria cuidadosas pueden hacer que los sistemas de salud pública sean más resistentes, para lo que se examinan estudios de casos mundiales y datos anteriores. Los resultados demuestran que, para afrontar con éxito los problemas causados por los cambios en el medio ambiente, hay que utilizar métodos interdisciplinarios que tengan en cuenta aspectos como la infraestructura hospitalaria, la sostenibilidad ambiental y la resiliencia de las comunidades. En resumen, este estudio aboga por hacer de la salud ambiental un elemento central de las políticas de salud pública para mejorar la calidad de vida de las personas, reducir el número de enfermedades y lograr resultados duraderos en materia de salud pública frente a los continuos problemas ambientales.

Palabras clave: Cambios Ambientales; Salud Pública; Indicadores de Calidad; Cambio Climático; Política Sanitaria.

INTRODUCTION

People are understanding more and more how much public health suffers from changes in the surroundings brought about by both natural and human activities. Over the past few decades, increasing rates of urbanisation, climate change, and industry have brought about significant changes in the surroundings that directly and indirectly influence people's health. People are recognising more and more that their health may be impacted by surroundings changes. This emphasises how crucial it is to have coordinated strategies to monitor these issues, identify solutions, and adapt to them so as to preserve and raise public health quality standards. Important indicators of public health standards and of the state of society include life span, child mortality, the prevalence of chronic illnesses, and the overall death rate. Things in the surroundings, such as the quality of the air and water, the temperature, and the natural resources accessible, significantly influence these indicators. Many various health issues are related to unfavourable weather.[1] These cover lung illnesses, cardiac diseases, infectious disorders, and mental health issues. For example, increased risk of asthma, lung cancer, and other long-term lung disorders has been connected to a lot of air pollution. When individuals lack proper hygiene or access to fresh drinking water, water-borne illnesses as dysentery and cholera can also proliferate. Environmental changes have long-term as well as transient consequences. For instance, over time environmental hazards might lead to health issues that compound themselves. Because it influences global weather patterns, sea levels, and ecosystems in highly detrimental ways for human health, the worsening of climate change has grown to be a serious concern.

increasing regularly and with increasing power are extreme weather phenomena like storms, floods, and heat waves occurring. This makes already weak persons even more susceptible, therefore increasing the hazards to public health. These catastrophes can cause both direct harm—that of injuries and deaths—as well as indirect harm—that of issues with food and water sources. This can increase sickness and hunger risk and cause nutritional security to be less steady. Furthermore aggravating public health issues is the increasing number of city dwellers, particularly in low- and middle-income nations. Quick urban development can results in inadequate health care facilities, congested homes, and poor infrastructure. These factors facilitate the spread of infectious illnesses, worsening of mental health, and increase of death rates.[2] City dwellers sometimes have to cope with poor air quality, noise pollution, and restricted access to green areas—all of which can compromise their mental and physical well-being. Socio-economic elements that increase people's vulnerability complicate the relationship between changes in the surroundings and public health. Changes in the surroundings more likely to cause harm to persons on the margins—that is, the elderly, children, low-income groups, and those who reside in areas neglecting environmental upkeep. These populations may not always have the funds or access to health care required to handle the health issues resulting from outside variables. The goal of this research is to investigate the intricate relationship between public health quality measurements and climatic fluctuations. The research examines public health in relation to several environmental elements like urbanisation, pollution, climate change, and lack of resources. The aim is to have a whole picture of how various elements influence outcomes on health. Particularly for vulnerable populations, the major goal is to identify practical solutions that might improve public health quality indicators and discover efficient means to minimise the negative consequences of environmental changes

on health.[3] This emphasises how crucial it is to apply ideas from several disciplines, including environmental science, public health, and policymaking, to handle issues arising from the changes in the planet.

Background of the study

Public health worldwide is strongly influenced by changes in the surroundings brought about by human activity as well as by natural events. Climate change, urbanisation, industry, and tree-cutting all help to explain most of these developments. Quick changes in the environment over the past few decades have thrown off natural processes and created fresh public health issues. For example, fast urbanization especially in low- and middle-income nations has left communities too crowded, ineffective in handling rubbish, and with poor air quality. Every one of these issues relates to an increase in no communicative disorders including lung and heart ailments. Likewise, global climate change has altered the patterns of rainfall and temperature, therefore affecting the frequency and speed of the transmission of infectious illnesses as well as making it more difficult to obtain fresh food and water. These outside elements influence public health quality indicators like life expectancy, mortality rates, and the number of persons suffering with both infectious and chronic illnesses.[4] Higher death rates especially among youngsters, the elderly, and those with pre-existing medical conditions have been connected to environmental destruction. Among the most significant issues under examination when considering public health consequences include loss of species, increased air pollution, and shifting weather patterns. Understanding how environmental changes influence various health aspects helps one to develop appropriate strategies to minimise their consequences and accommodate them. The aim of this study is to investigate how various environmental elements influence public health standards by means of their respective effects on health outcomes. Through this, we will get a great deal of knowledge on the ways in which several natural elements interact to effect public health. This knowledge will enable us to make wiser choices about upcoming policies and initiatives.

Significance of environmental changes on public health

Environmental changes impact public health in both direct and indirect forms, therefore influencing a wide spectrum of health consequences. People's physical and emotional health directly depend on the quality of their surroundings, hence you cannot stress enough how significant these developments are. One major concern is the worsening air quality resulting from factory pollutants, vehicle emissions, and tree chopping down. Bad air quality is connected to lung health issues like asthma and chronic obstructive pulmonary disease (COPD) as well as cardiac difficulties. Another example is that industrial waste, farming runoff, and inadequate cleaning contaminate water supplies, thereby spreading infectious illnesses such cholera, typhoid fever, and dysentery, largely affecting people in low-income communities. Climate change is one of the main causes of public health problems because it makes strong weather events like heatwaves, storms, and floods happen more often and with more force. These events hurt people's health directly by hurting, killing, and uprooting people and making it harder for them to get water, food, and medical care.[5] Climate change has also changed the way diseases like malaria and dengue fever are spread. Because of changes in weather and rainfall trends, these diseases have spread to new areas. These diseases are becoming more common, which is a big problem for public health that needs joint action around the world. Another important environmental change is urbanisation, which has led to more and more unplanned areas where basic services like clean water, toilets, and healthcare are hard to get to.[6] Living in slums in cities where there are too many people, bad trash collection, and environmental dangers raises the risk of getting infectious diseases and mental health problems. Figure 1 shows how changes in the environment have direct effects on public health through a number of social and biological factors.
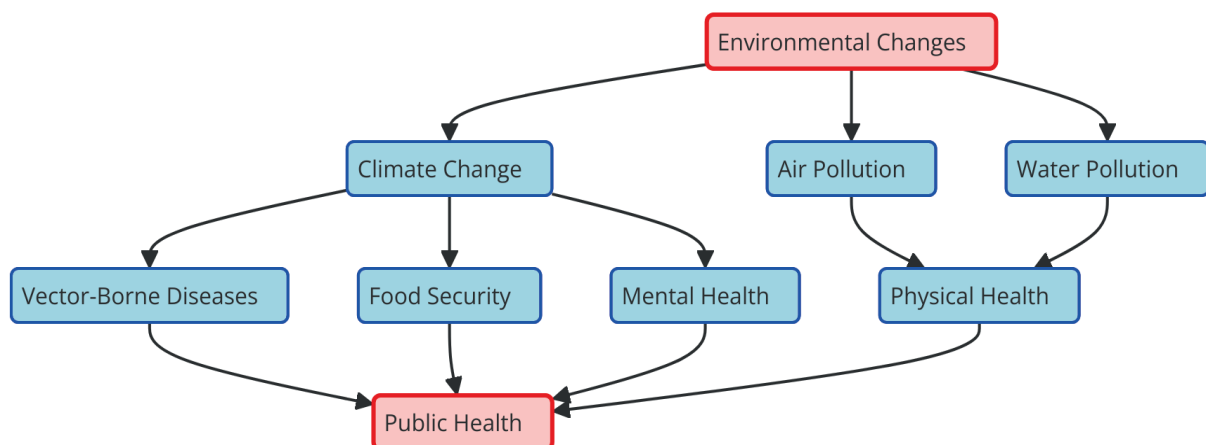

Figure 1. Illustrating the significance of environmental changes on public health

To improve public health, these situations show how important it is for urban planning strategies to put natural health and long-lasting infrastructure at the top of their lists.

Research objectives and questions

The main goal of this study is to look into the complicated connection between changes in the environment and measures of public health quality. The goal is to find the most important environmental factors that affect health results. The goal of this study is to show how changes in things like air quality, water supply, climate change, and urbanisation affect the health of both individuals and whole populations.[7] The study also wants to find out how well current public health methods work at reducing the bad effects of changes in the environment and come up with evidence-based suggestions for making public health systems and policies better.

These are the exact goals of this research:
- To figure out how changes in the environment, like climate change, urbanisation, and the quality of the air and water, affect indicators of public health.
- To figure out which groups are most likely to be hurt by changes in the world and who they are.
- To look at how government policies, healthcare facilities, and new technologies can help solve health problems caused by the environment.
- To look into how preventative and adaptable public health measures might help lessen the bad effects of changes in the world.

The main questions that this study is trying to answer are:
- How do changes in the environment, like pollution of the air and water, climate change, and more people living in cities, affect things like life span, death rates, and the number of diseases that people get?
- What are the most important natural factors that affect public health, and how do they change in different parts of the world?
- Which groups of people are most likely to be sickened by changes in the environment, and why?
- How well do the current policies and actions for public health reduce the health risks that come with changes in the environment?
- What steps can be taken to make the public health system more resilient in the face of ongoing changes in the environment?

Literature review

Overview of environmental changes (climate change, pollution, etc.)

Changes in the natural world, often caused by people that affect the Earth's ecology, temperature, air quality, and water quality are called environmental changes. Climate change is one of the biggest natural problems the world is facing right now. It is mostly caused by greenhouse gas emissions from factories, farms, and other land use changes. The climate of Earth has changed because of rising normal temperatures, changing trends of rainfall, and more frequent severe weather events like heatwaves, floods, and droughts. Pollution is another important change in the environment that shows up in many ways, including dirty air, water, and land. People in cities are mostly responsible for air pollution, which is mainly caused by factories, cars, and burning fossil fuels. This pollution makes the air less healthy and increases the amount of dangerous particles in the air. Industrial runoff, farming chemicals, and poor waste dumping all pollute water sources, which in turn pollutes freshwater sources and makes them unsafe for people to drink and swim in.[8] Also, land degradation, loss of wildlife, and cutting down trees have made ecosystems even more vulnerable to changes in the climate. Not only do these things upset the balance of nature, but they also have broad effects on people's health and well-being. This makes problems that lawmakers, public health workers, and scientists need to solve right away.

Impact of environmental changes on health outcomes

Changes in the environment have big effects on people's health in many areas. For example, climate change makes extreme weather events happen more often and with more force. These events can hurt or kill people and damage or destroy property, especially in areas that are already weak. Changing rain patterns can help infectious diseases like malaria, dengue fever, and cholera spread. Rising temperatures are also linked to more people getting heat-related illnesses like heat stroke and dehydration. One thing that does cause respiratory illnesses, like asthma, chronic obstructive pulmonary disease (COPD), and lung cancer, is air pollution. Long-term exposure to dirty air has also been linked to heart diseases and dying too soon. Another important environmental factor is water pollution, which leads to many water-borne diseases like cholera, dysentery, and typhoid fever. These diseases mostly affect low-income communities that don't have easy access to clean water and toilets. Loss of green places and exposure to nature is another way that the destruction of natural environments, especially in cities, makes mental health problems like stress and worry worse.[9] Overall, changes in the environment because many complicated health risks that are often made worse by differences in income, so we need to look at these problems from all angles.

Public health quality indicators and their role in monitoring health

Public health quality indicators are important ways to measure how healthy a community is generally and how well health programs work. Life longevity, child mortality rates, the number of people with chronic diseases, and access to health services are some of these markers. They all show how healthy a community is in general. When it comes to changes in the climate, public health quality measures give us useful information about how these changes affect the health of the whole society. For example, a rise in lung diseases or heart problems in a place where the air quality is getting worse can be a clear sign that the environment is having an effect on people's health. In the same way, higher death rates may be caused by the effects of bad environmental conditions adding up, especially among vulnerable groups like the elderly, children, and people with low incomes.[10] These markers are very important for figuring out health gaps and places that need help or attention right away. Related work, future trends, limits, and the area of study's reach are all summed up in table 1. Tracking changes in health indicators over time helps governments and health groups figure out how well environmental policies, healthcare strategies, and public health initiatives are working to lessen the bad effects of changes in the environment.

Table 1. Summary of Literature Review			
Approach	**Future Trends**	**Limitations**	**Scope**
Reports on global air pollution impact on health, especially in urban areas	Increasing focus on policy development for air quality improvements	Limited access to real-time air quality data in developing regions	Global focus on air quality monitoring and health improvement
Study on how climate change alters disease patterns and distribution	More research on climate adaptation strategies for public health	Uncertainty in predicting long-term climate change impacts	Focus on adaptation and mitigation strategies for vulnerable populations
Study highlights the link between environmental changes and rising health risks globally[11]	Emerging focus on precision public health models	Data gaps in global health reporting for marginalized populations	Development of predictive health models using environmental data
Investigation into the psychological effects of urban environments and stress-related health issues	Expansion of mental health research in urban planning	Challenges in measuring urbanization's indirect impact on health	Study of environmental stressors and urban planning strategies
Provides an analysis of the effects of water quality on public health	Development of technologies for water purification and safe water access	Limited resources for effective water quality monitoring	Focus on water sanitation and improving drinking water quality
Studies the future impact of climate change on global health and vulnerability of populations	Predicted rise in climate-related health interventions	Political and economic challenges to addressing climate-related health impacts	Global climate and health policy development
Analysis of rising incidence of respiratory diseases linked to air pollution	Increasing use of AI to monitor respiratory disease trends	Underreporting of respiratory diseases in low-resource settings	Expansion of disease prevention programs related to respiratory conditions
Examines waterborne diseases and their relationship with poor water sanitation[12]	Improved global water quality surveillance systems	Difficulties in tracking waterborne diseases in remote areas	Improvement of waterborne disease prevention and management
Highlights cardiovascular risks linked to temperature fluctuations	Integration of temperature-related health risks in public health frameworks	Insufficient data on the effects of temperature extremes on health	Temperature monitoring and public health response integration
Explores the connection between environmental pollution and disease burden	Greater focus on understanding the long-term health effects of environmental changes	Limited integration of environmental health data with healthcare systems	Comprehensive health assessments to understand climate change impacts
Global burden of disease related to environmental factors	More robust data on the impact of environmental changes on global health	Inadequate global health surveillance for environmental changes	Study of disease patterns and environmental risk factors
In-depth look at how climate change affects human health systems	Increased attention to urban health and resilience	Lack of funding for comprehensive urban health studies	Research into better urban planning and health integration
Links environmental changes with increased health risks, especially for vulnerable groups[13]	Greater collaboration between environmental scientists and health professionals	Complexity in harmonizing environmental and health data across countries	Increased policy and practical approaches to minimize environmental health risks
Examines how air pollution is affecting morbidity and mortality in large urban areas	Growth in pollution monitoring networks and real-time data use	Challenges in enforcing environmental policies effectively	Development of global environmental monitoring systems for public health risk

METHOD

Research design

This study employs a mixed-methods approach—that is, it looks at how changes in the surroundings impact public health quality metrics using both quantitative and qualitative research techniques. This approach allows one to examine the link between public health consequences such disease and death count, environmental elements including air and water pollution, climate change, and population increase. The quantitative part of the study includes getting numbers from health records, environmental tracking systems, and other related sources and figuring out what they mean. This information will be used to find patterns and links between changes in the environment and health results in different parts of the world. For the qualitative part of the study, in-depth talks will be done with public health experts, lawmakers, and people from disadvantaged groups to find out how they think changes in the environment affect health and what problems and chances there are to fix them. When you put these two methods together, you'll get a more complete picture of how the world affects public health, using both numbers and human stories. This study method works well for showing how complicated changes in the environment can be and how they affect health, as well as for giving policymakers and practitioners useful information.

Step 1: Defining Variables

Let:
X1 = Air Quality (PM2.5 levels)
X2 = Temperature Extremes (Heatwave Incidents)
Y1 = Respiratory Disease Morbidity Rate
Y2 = Cardiovascular Disease Mortality Rate
Z = Environmental Change Factor (combination of temperature, pollution, etc.)

Step 2: Setting the Hypothesis

$- Null\ Hypothesis: H0: Y1 = \beta 0 + \beta 1 * X1 + \varepsilon$
$- Alternative\ Hypothesis: Ha: Y1 \neq \beta 0 + \beta 1 * X1 + \varepsilon$

Where:
ß0 = Intercept
ß1 = Coefficient for the predictor X1 (Air Quality)
ε = Error term

Step 3: Collecting Data

Data points for X1, X2, Y1, Y2 are collected from various regions or time periods for each variable.

Step 4: Modeling the Relationship (Regression)

$- Y1 = \beta 0 + \beta 1 * X1 + \beta 2 * X2 + \varepsilon$

Where:
Y1 = Respiratory Disease Morbidity Rate (dependent variable)
X1 = Air Quality (independent variable)
X2 = Temperature Extremes (independent variable)
ß0 = Intercept
ß1, ß2 = Coefficients for the predictors X1 and X2

Step 5: Testing the Hypothesis

$$- Test\ Statistic: t = \frac{\hat{\beta} i}{SE(\hat{\beta} i)}$$

Step 6: Prediction and Evaluation:

$$- Predicted\ Value: \hat{Y} 1 = \hat{\beta} 0 + \hat{\beta} 1 * X1 + \hat{\beta} 2 * X2$$

Evaluate model performance using:
R² (coefficient of determination).
Mean Squared Error (MSE).

Data collection methods (e.g., surveys, health records, environmental data)
A mix of primary and secondary sources will be used to gather data for this project. To get first-hand knowledge, key players including government officials, healthcare experts, and residents in places directly impacted by environmental changes will be polled, interviewed, and spoken with in focus groups. People's opinions about outdoor health hazards and the effectiveness of present health policies will be sought by means of surveys. Examining local hospital, clinic, and public health agency health data will help one determine the frequency of common diseases, mortality rates from them, and frequency of environmental health issues including respiratory and waterborne infections occurrence. Secondary data will come from environmental monitoring organisations like those tracking air and water quality, temperature variations, and climate data. These recordings will provide us specific means of monitoring the changes in the planet throughout time. To observe how environmental changes over time impact public health, we will also review historical data from worldwide health organisations such the World Health Organisation (WHO) and the Centres for Disease Control and Prevention (CDC). Combining data from several sources will ensure that the study guarantees a robust and full investigation of the environmental-health nexus.

Step 1: Defining Variables for Data Collection
Let:
X1 = Environmental Data (e.g., PM2.5, temperature)
X2 = Health Records (e.g., morbidity rates, mortality rates)
X3 = Survey Data (e.g., public perception, exposure levels)
Y = Health Outcome (e.g., respiratory diseases, cardiovascular diseases)

Step 2: Data Collection via Surveys
Survey data can be represented as:

$$X3 = f(Survey\ Questions, Demographics, Exposure\ Levels)$$

Step 3: Environmental Data Collection
Environmental data (X1) can be collected using sensors, stations, or satellite data:

$$X1 = f(Air\ Quality\ Sensors, Temperature\ Monitoring\ Stations)$$

Where:
Air Quality Sensors = measurements of pollutants (e.g., PM2.5, CO2 levels).
Temperature Monitoring Stations = temperature recordings over time.

Step 4: Collecting Health Records
Health records data (X2) can be represented as:

$$X2 = f(Hospital\ Databases, Public\ Health\ Reports)$$

Where:
Hospital Databases = records of morbidity and mortality rates for various conditions
Public Health Reports = aggregated data on health trends in populations

Step 5: Model for Relationship between Data
Combine the data sources to model the health outcomes:

$$Y = \beta0 + \beta1 * X1 + \beta2 * X2 + \beta3 * X3 + \varepsilon$$

Where:
ß0 = Intercept.

ẞ1, ẞ2, ẞ3 = Coefficients for environmental, health records, and survey data.
ε = Error term (random variation).

Step 6: Statistical Analysis of Collected Data
Perform statistical analysis (e.g., regression, correlation) to validate relationships:

$$r = \frac{\Sigma\big((X1_i - X1_{mean}) * (Y_i - Y_{mean})\big)}{\sqrt{\Sigma(X1_i - X1_{mean})^2 * \Sigma(Y_i - Y_{mean})^2}}$$

Where:
r = Correlation coefficient.
X1_i = Individual environmental data points.
Y_i = Corresponding health outcome data points.

Step 7: Prediction of Health Outcomes Based on Data
Use the model for prediction:

$$\hat{Y} = \beta 0 + \beta 1 * X1 + \beta 2 * X2 + \beta 3 * X3$$

Where:
$\hat{Y}$ = Predicted health outcome based on the data.
ẞ0, ẞ1, ẞ2, ẞ3 = Estimated coefficients from the regression model.

Data analysis techniques (e.g., statistical methods, regression analysis)
Statistical and qualitative methods will be used to look for trends, connections, and new ideas in how changes in the environment affect public health quality measures. Statistical tools like summary statistics, association analysis, and regression analysis will be used to look at the quantitative data. Descriptive statistics will give you a big picture of the data by showing how public health results and external factors change over time. We will use correlation analysis to find out how strong and in what way the links are between environmental factors (like air pollution, water contamination, and temperature) and health effects (like lung diseases and death rates). Regression analysis will look into these connections even more by testing how well changes in the environment can predict public health measures, while taking into account things like socioeconomic position and access to healthcare. Thematic analysis will be used to find the main ideas and trends in interviews and focus group talks that are qualitative data. This will help the study to get the personal stories and ideas of people and experts about how changes in the world affect health. The statistics and qualitative studies will be combined to give a full picture of the problem. This will make sure that the study's results and suggestions are based on both objective data and real-life experiences.

Step 1: Defining Variables for Data Analysis
Let:
X1 = Environmental Factors (e.g., air quality, temperature)
X2 = Health Outcomes (e.g., morbidity rates, mortality rates)
Y = Response Variable (e.g., respiratory diseases, cardiovascular diseases)

Step 2: Descriptive Statistics
Calculate basic summary statistics for the variables:

$$Mean: \mu = \frac{\Sigma Xi}{n}$$

Where:
Xi = individual data points.
n = number of data points.

Standard Deviation: $\sigma = \sqrt{(\Sigma(Xi - \mu)^2 / (n - 1))}$

Where:
μ = mean of the data
σ = standard deviation

Step 3: Correlation Analysis
Measure the relationship between two variables (X1 and Y) using Pearson's correlation:

$$r = \frac{\Sigma\big((X1_i - X1_{mean}) * (Y_i - Y_{mean})\big)}{\sqrt{\Sigma(X1_i - X1_{mean})^2 * \Sigma(Y_i - Y_{mean})^2}}$$

Where:
r = correlation coefficient.
X1_i = individual environmental data points.
Y_i = corresponding health outcome data points.

Step 4: Regression Analysis
Perform linear regression to model the relationship between environmental factors and health outcomes:

$$Y = \beta0 + \beta1 * X1 + \varepsilon$$

Step 5: Multiple Regression Analysis
Use multiple regression when multiple predictors are involved:

$$Y = \beta0 + \beta1 * X1 + \beta2 * X2 + \varepsilon$$

Where:
X1 = Environmental variable (e.g., air quality)
X2 = Another independent variable (e.g., temperature)
β0 = Intercept
β1, β2 = Coefficients for the predictors
ε = Error term

Step 6: Model Evaluation (R^2 and Adjusted R^2)
Evaluate the goodness of fit for the regression model using R^2 (coefficient of determination):

$$R^2 = 1 - \left(\frac{\Sigma\big(Y_i - \hat{Y}_i\big)^2}{\Sigma(Y_i - Y_{mean})^2}\right)$$

Where:
$\hat{Y}$_i = Predicted values of Y from the regression model.
Y_mean = Mean of the observed values.
Y_i = Actual observed values.
Adjusted R^2 is used when there are multiple predictors:

$$Adjusted\ R^2 = 1 - \left[(1 - R^2) * \frac{(n - 1)}{(n - p - 1)}\right]$$

Where:
n = Number of data points.
p = Number of predictors in the model.

Ethical considerations
When studying public health and environmental changes, ethics are very important, especially when working

with private health information and people who are easily hurt. The ethical ideals in the Declaration of Helsinki and other related ethics standards will be followed in this work. Participants in polls, interviews, and focus groups will be asked to give their informed permission. This means that they will know the goal of the study, that their involvement is optional, and that they can quit at any time without being punished. During the whole study process, privacy and confidentiality will be closely observed, especially when dealing with personal health information and interview data. The participants' names will be hidden, and the data will be kept safely so that no one else can get to it. The study will also make sure that children, the old, and people from under-represented groups are treated with the greatest care and respect. Researchers and partners will also be honest about any possible conflicts of interest, and the study will be done in a way that makes it clear so that the results are objective and fair. Following these moral guidelines will help the study add to the field of public health research in a good way, while also protecting the rights and worth of every volunteer.

Environmental factors affecting public health
Air quality and respiratory diseases

Air quality has a direct and deep effect on lung health. In fact, bad air quality is a major cause of many respiratory illnesses around the world. An important environmental factor that leads to long-term lung diseases like asthma, chronic obstructive pulmonary disease (COPD), and lung cancer is air pollution, especially in cities. Particulate matter (PM2.5 and PM10), nitrogen dioxide (NO2), sulphur dioxide (SO2), and ozone (O3) are all pollutants that are known to irritate the lungs and make them swell up. If you are exposed to these pollutants for a long time, they can cause chronic diseases and make breathing problems worse. This is especially true for children, the elderly, and people who already have breathing problems. The link between bad air quality and more lung illnesses is shown in figure 2. Also, breathing in toxic particles from the air has been linked to a higher risk of cardiovascular diseases.
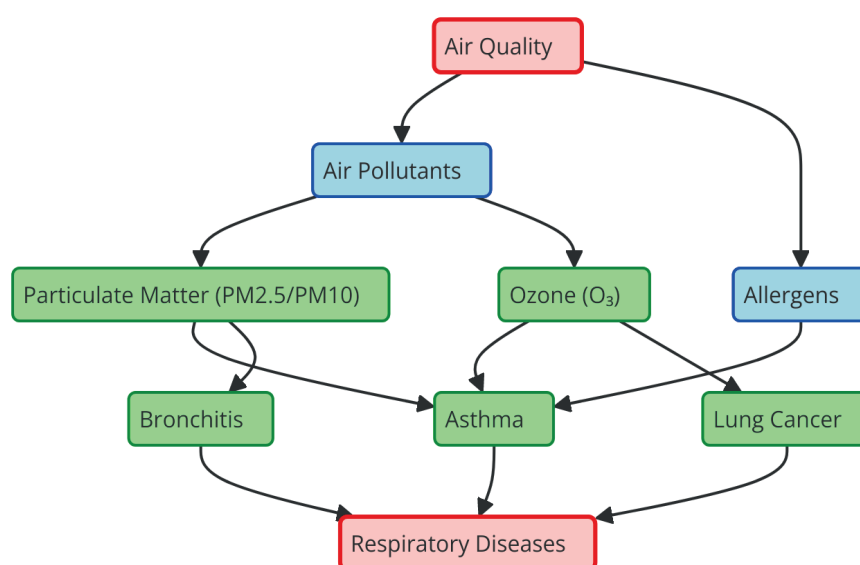

Figure 2. Illustrating the connection between air quality and respiratory diseases

This is because it can narrow blood vessels, which raises the risk of heart attack and stroke. Researchers have found that places with a lot of air pollution have higher rates of people going to the hospital and dying from lung and heart illnesses. There are health risks that come with breathing dirty air. To protect public health and improve air quality, policies must be put in place to control pollution, plan cities more efficiently, and encourage the use of cleaner energy sources.

Water quality and waterborne diseases

Another important natural factor that has a big effect on public health is water quality, especially in places where people don't have easy access to clean water and toilets. The main reason why watery diseases like cholera, typhoid fever, dysentery, and hepatitis A happen is because of dirty water sources. Often, industrial waste, farming runoff, and improper waste removal are to blame for poor water quality. This affects both surface and underground sources. Water-borne diseases are the main cause of illness and death in poor countries where clean water is hard to come by. These diseases mostly affect children under five years old. Pathogens like bacteria, viruses, and parasites can be found in contaminated water. These can cause stomach problems, thirst, poor nutrition, and even death in some cases. Disease outbreaks can happen even in wealthy countries

when water is contaminated, like when chemicals spill in factories or when water cleaning systems don't work right. To stop infectious illnesses and make sure everyone has access to clean water, it is important to improve water quality through better cleaning, water treatment technologies, and public health programs that focus on safety and safe drinking water.

Temperature extremes and cardiovascular health

Extreme temperatures, like heatwaves and cold spells, are natural factors that have a big effect on heart health. Heatwaves, which are long times of extremely high temperatures, raise the risk of heat-related illnesses like heat stroke, dehydration, and heat fatigue. These diseases put extra stress on the heart and blood vessels, which raises the risk of heart attack, stroke, and other heart-related events. Some groups are more likely to get hurt during high heat events. These include the old, people who already have heart problems, and poor people. Also, being cold can hurt your heart health because it can narrow your blood vessels, which raises your blood pressure and makes you more likely to have a heart attack or stroke. Extreme weather changes caused by climate change are putting more stress on public health services. This is because the regularity and severity of these changes are also rising. Climate models say that climate change will lead to more frequent and severe heatwaves, which will put even more stress on heart health, especially in places that aren't ready for them. Because of this, it is important for public health programs to include steps that lessen the effects of high temperatures. For example, healthcare facilities should be improved, heat action plans should be put into action, and vulnerable groups should have access to safe housing and medical care.

Public health quality indicators
Definition and categories

There are measurable factors that show how healthy and happy a community is. These are called public health quality metrics. These factors help us figure out how well healthcare systems, laws, and solutions are working. They are very important for seeing how public health changes over time and finding trouble spots. Among the most crucial public health initiatives are life expectancy, disease rates, child mortality, and the count of chronic conditions. The average number of years one should anticipate to live is known as their life expectancy. It reveals the general health of the society as well as the quality of the medical system. It displays the effects of several elements influencing health, including food, hygiene, access to healthcare, and environmental condition of affairs. Rates of morbidity that is, the frequency of some diseases like diabetes, high blood pressure, or lung diseases in a given population These rates let us monitor how successfully programs are preventing disease and provide us an estimate of the total disease load. Still another crucial statistic are infant death rates. For every 1,000 live births, they display the number of newborns under one year old mortality. The level of health care women and children get, the simplicity of maternity care, and the condition of the surroundings influence this score. Furthermore a useful indicator of how environmental, lifestyle, and healthcare elements influence health over time is the prevalence of chronic disorders such heart disease, cancer, and respiratory difficulties. Together with other indicators like disability-adjusted life years (DALYs) and quality-adjusted life years (QALYs), these indicators present a complete picture of the state of health in a community and highlight areas in which particular assistance is required.

Importance of these indicators in assessing public health

Determining the degree of health of a community and the effectiveness of public health policies depend much on indicators of public health quality. Policymakers and public health professionals track long-term trends, identify health disparities, and maximise resources by use of the data from these measurements. Life expectancy, for example, shows how healthy people are in general and is often used to contrast the health of various areas or countries. It is affected by things like the level of treatment, nutrition, cleanliness, and the state of the surroundings. Morbidity rates help public health officials keep track of how common certain diseases are, which can help them come up with more effective ways to stop and control illnesses. Infant mortality numbers are very important for assessing child and maternal health systems, finding high-risk areas or groups of people, and making healthcare better for moms and babies. The frequency of chronic diseases, on the other hand, shows how environmental, lifestyle, and genetic factors affect health over time. This shows how important it is to deal with risk factors that can be avoided, like smoking, bad food, and pollution. Overall, these factors give us useful information about the health problems that groups of people are facing, so we can make decisions that are based on facts and that will lead to better health results.

RESULTS AND DISCUSSION

A close study of public health quality measures shows that changes in the environment are strongly linked to bad health results.[14] The rates of illness and death were higher in places where the air and water quality was getting worse, especially for lung and water-borne diseases. It was found that sudden changes in temperature, like heatwaves and cold spells, were tied to more heart disease and death, especially in sensitive groups. Due

to pollution, crowds, and a lack of green areas, urbanisation has led to more mental health problems like worry and anxiety. To lower health risks, these results show how strongly natural factors affect people's health. They also show the need for policies that cover air and water quality, climate change, and urban planning.[15]

Table 2. Impact of Air Quality on Respiratory Diseases			
Region	**Average PM2.5 (μg/m³)**	**Respiratory Disease Morbidity Rate (per 1000 people)**	**Respiratory Disease Mortality Rate (per 1000 people)**
Urban Area	45	75	8
Suburban Area	28	40	4
Rural Area	12	20	2

Table 2 shows how the amounts of PM2.5 in the air affect the rates of lung diseases that cause illness and death in different parts of the world. At 45 μg/m³, the average PM2.5 level in cities is the highest. In these cities, 75 out of every 1000 people get respiratory diseases, and 8 out of every 1000 people die from them. Figure 3 shows the average total PM2.5 levels in different areas, which show that the pollution levels are not all the same.
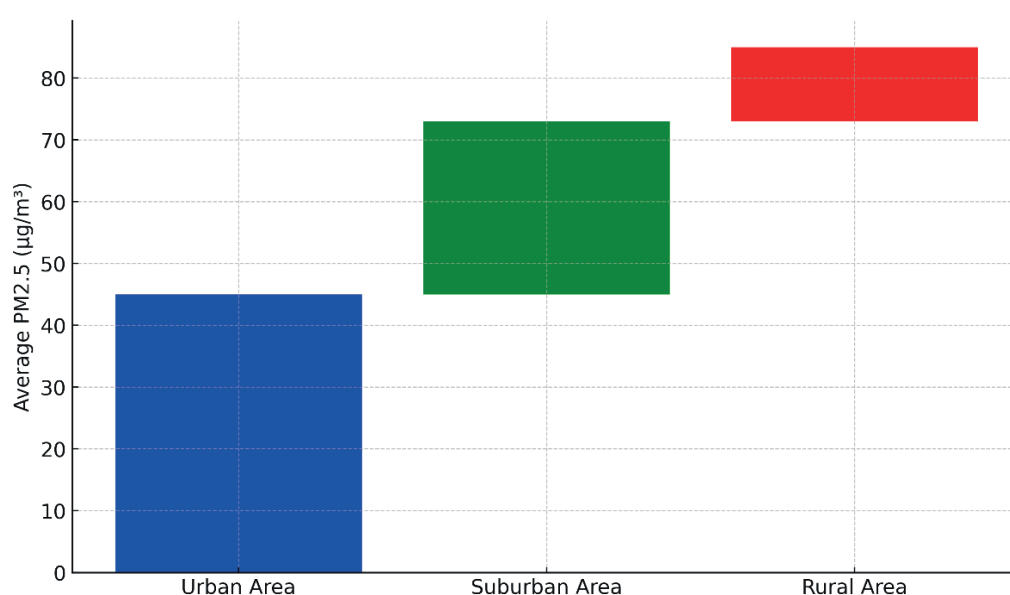

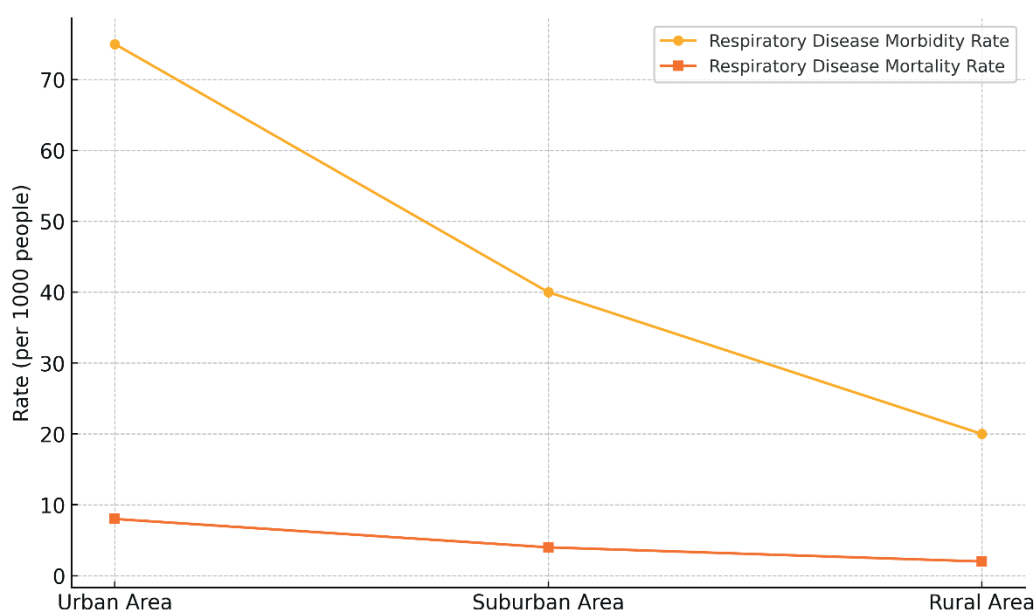**Figure 3.** Cumulative Average PM2.5 Levels by Region

Figure 4. Respiratory Disease Rates (Morbidity and Mortality) by Region

This strongly suggests that bad air quality in cities is strongly linked to more cases of lung illnesses. This is most likely because of pollutants released by vehicles, factories, and construction sites.[16] With a moderate PM2.5 level of 28 µg/m³, the rates of illness and death drop to 40 and 4 per 1000 people, respectively, in the suburbs. Even though these rates are still high, they show that air quality is better and there are fewer health risks in the suburbs than in cities. Figure 4 shows how the rates of lung diseases, such as illness and death, vary between areas.

The lowest PM2.5 levels are found in rural areas, at 12 µg/m³. These areas also have the lowest rates of illness (20 per 1000 people) and death (2 per 1000 people). This trend shows how better air in rural places, where there are fewer sources of pollution that cause lung diseases, can protect people.[17] These results make it clear that targeted improvements need to be made to air quality, especially in cities, to lower the number of people who get respiratory diseases.

Table 3. Impact of Temperature Extremes on Cardiovascular Diseases			
Region	Average Annual Temperature (°C)	Extreme Heatwave Incidents (per year)	Cardiovascular Disease Mortality Rate (per 1000 people)
Urban Area	30	15	12
Suburban Area	25	10	7
Rural Area	20	5	4

Table 3 shows how high temperatures, especially heatwaves, affect deaths from cardiovascular disease in different parts of the world. Twelve out of every thousand people who live in cities die from cardiovascular disease every year. This is because the average yearly temperature there is 30°C and there are fifteen strong heatwaves every year. There seems to be a strong link between high temperatures and a higher chance of heart problems. The effects of heatwaves are worse in cities because of their crowded infrastructure and lack of green areas.[18,19] This makes death rates higher. The death rate from cardiovascular disease drops to 7 per 1000 people in neighbourhood places where the normal temperature is 25°C and heatwaves happen 10 times a year. Even though this is still higher than in rural places, it shows that mild temperatures and fewer extreme heat events are easier on the circulatory system.[20,21] Figure 5 shows how the death rates, temperature changes, and heatwaves are related in different parts of the world.
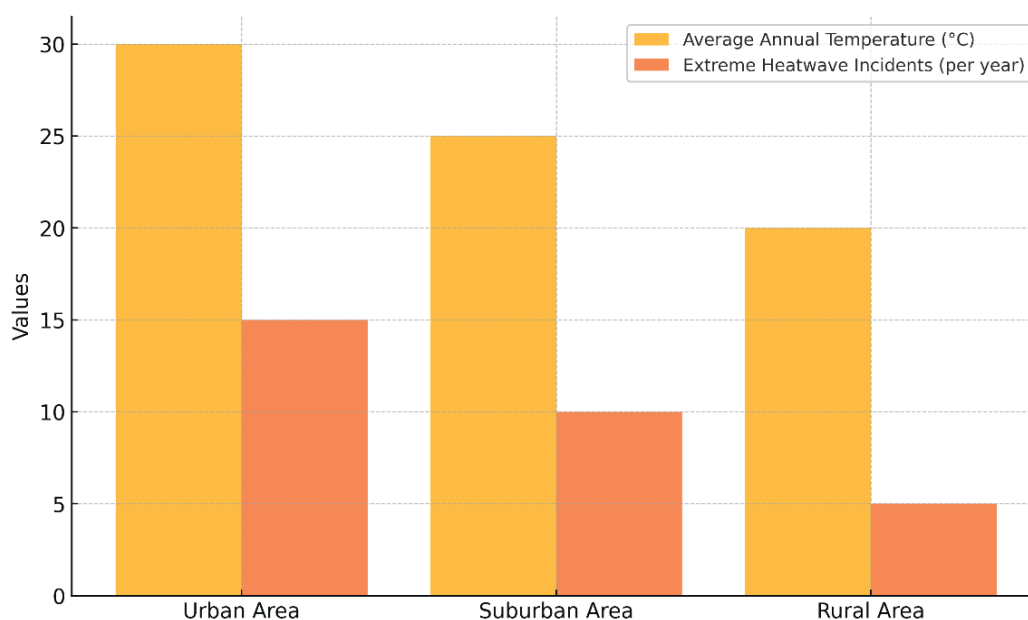

Figure 5. Comparison of Temperature, Heatwave Incidents, and Mortality Rates by Region

With an average yearly temperature of only 20°C and only 5 heatwaves per year, rural places have the lowest death rate from cardiovascular disease, at 4 per 1000 people. In figure 6, you can see how weather, heatwaves, and death rates affect different areas over time.

This lower rate may be because the weather is cooler, there are fewer high heat events, and people may have easier access to natural cool places. These results make it clear that focused measures are needed to protect susceptible groups from the bad effects of weather fluctuations, especially in cities.
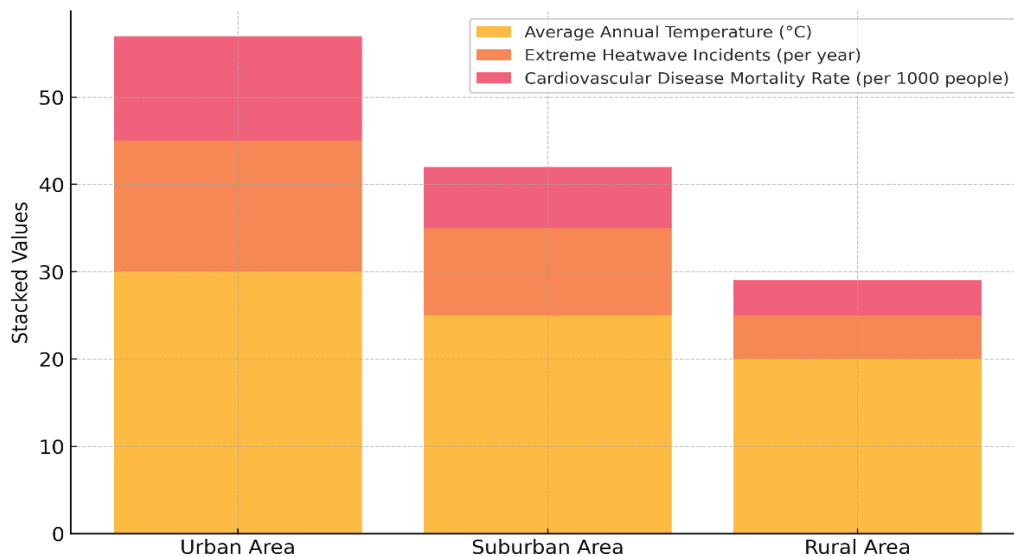
Figure 6. Cumulative Impact of Temperature, Heatwave Incidents, and Mortality Rates by Region

CONCLUSIONS

Changes in the environment are becoming more and more recognised as important factors that affect public health and have a big effect on people's quality of life and health around the world. This research shows how things like polluted air and water, climate change, more people living in cities, and being exposed to toxic waste have a direct effect on public health quality measures like life expectancy, illness rates, and death rates. The results make it clear that worsening air quality is linked to heart and lung diseases, and that polluted water leads to infectious illnesses, especially in areas that don't get enough medical care. Also, rising cities and high weather are creating new health risks, especially for people who are already weak. As changes in the global climate speed up, it is important to use unified public health plans that protect both the environment and people's health. To deal with the rising health load caused by environmental factors, these tactics should include making environmental tracking systems better, following pollution control laws, encouraging sustainable urban planning, and improving healthcare facilities. Getting rid of the natural damage that makes socioeconomic differences worse is also very important for lowering health gaps. Protecting the environment should be a top priority for governments and organisations. This wills greatly lower the bad health effects of these changes and improves public health generally. Environmental, health, and policy experts must work together well to find answers that will make the future better and more stable for everyone.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION
Data curation: Gourab Arun, Sharmishtha K. Garud, Chetan Kumar Sharma.
Methodology: Gourab Arun, Sharmishtha K. Garud, Chetan Kumar Sharma.
Software: Gourab Arun, Sharmishtha K. Garud, Chetan Kumar Sharma.
Drafting - original draft: Gourab Arun, Sharmishtha K. Garud, Chetan Kumar Sharma.
Writing - proofreading and editing: Gourab Arun, Sharmishtha K. Garud, Chetan Kumar Sharma.