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Review Article

Infections Related to Climate Change and Possible Solutions

A. Ramesh, Anand B Janagond, G. S. Vijay Kumar
[1,2]Associate Professor,Department of Microbiology, Velammal Medical College Hospital, Madurai, India
[3]Professor and Head, Department of Microbiology, Velammal Medical College Hospital, Madurai, India

***Corresponding author**
Dr. Anand B. Janagond
Email: anandbj@gmail.com

Abstract: Changes in the climatic conditions have reached such a magnitude that possibility of man-induced mass extinction is being considered if suitable measures are not taken. Climate change favours certain air-borne, water-borne and food-borne infections by augmenting the virulence and/or favouring the spread of infectious agents. This is a cause of concern in developing countries, which are already burdened with infectious diseases and population explosion. Increased toxic components in the air damages respiratory system and predisposes to infections. Global warming induced erratic rainfall, falling agricultural output, etc have decreased availability of potable water and quality food in sufficient quantities. Vector –borne infections are on the rise due to changing distribution, reproductive and biting habits of the vectors which are in turn attributed to climate change. Treating affected individuals and prevention of environmental damage must go hand in hand. This article focuses on infections associated with climate change and proposes various suggestions to improve the situation both at individual level and at the community level in the Indian context. Judicious use of fossil fuels and adapting to renewable sources of energy prevents emission of green-house gases and thus controls global warming. Proper usage of available water, rain water harvesting, afforestation, recycling of water are important measures to ensure availability of potable water for everyone. Along with measures to increase quality food production, steps for effective post-harvest management are necessary for reducing wastage and achieving proper distribution of food. Data required for the review was gathered from various Govt. Publications and published articles.
Keywords: Climate change, Global warming, Infections, air-borne, Water-borne, Food-borne, Infection management.

INTRODUCTION

Global warming is a cause of concern for all human beings inhabited on earth. Recent reports have suggested the possibility of sixth mass extinction [1] which unlike the previous ones is predominantly due to unregulated human activities (anthropogenic climate change) [2] leading to exploitation of environment resulting in problems like global warming [3]. In 2001, the UN General Assembly has declared 6 November of each year as the International Day for Preventing the Exploitation of the Environment in War and Armed Conflict. Healthcare settings are already burdened with the daunting task of tackling communicable and non-communicable diseases and the current scenario of climate change poses an additional burden in the form of emerging infectious and other non –infectious diseases [4]. Developing countries tend to bear the brunt of climate related damage caused by industrialized nations.

Climate change is associated with allergic disorders, malignancy, depression, malnutrition, infections, etc. [5, 6]. It also favours certain air-borne, water-borne and food-borne diseases by augmenting the virulence and/or favouring the spread of infectious agents. This is a cause of concern in a country like ours which is already burdened with infectious diseases and population explosion. Treating affected individuals and prevention of environmental damage must go hand in hand. If not, it will have an impact on health indices like morbidity and mortality and on economic indices like GDP. A recent study by the World Bank on Indian economy says that, about 5.7% of GDP is affected by environmental degradation [7]. All these will culminate in decreased productivity, higher demand, increased disease burden and diminished economic growth. When economy is disturbed, then public spending on health will rise and thus a vicious cycle will set in. This article focuses on infections associated with climate change and proposes various suggestions to improve the situation both at individual level and at the community level in the Indian context. Data required for the review was gathered from various Govt. Publications and published articles.

Climate change induced selection pressure can enhance virulence and pathogenicity. More over organisms which are not known to cause human diseases are now being reported in human infections. The implication is that, unplanned development of

human race is a direct threat to almost all other living beings and in the long run to human being themselves.

CLIMATE ASSOCIATED HEALTH ISSUES

Climate associated health care issues are many and include communicable and non-communicable disorders [8]. Rise and spread of communicable disorder is a challenge to the society in the background of diminished funding, lack of manpower, non-availability of adequate infrastructure and clean, safe environment.

AIR BORNE INFECTIOUS DISEASES

Respiratory illnesses are rising due to accumulation of greenhouse gases like carbon dioxide, sulphur dioxide, etc. Exposure to these and superadded infections can cause considerable damage to the respiratory epithelium [9]; which compromises respiratory functions leading to pneumonia, pulmonary tuberculosis, etc. [10] and aggravation of seasonal infections. Presence of co-morbid conditions like diabetes mellitus, a very common condition in India, complicates the situation. A recent study has revealed that diabetes increases the risk of TB by three folds [11].

There are multiple incidents of accidental inhalation of toxic fumes by public and chronic inhalation of toxic fumes in work places. These, especially the latter are occurring at subclinical level and cumulative effect of such exposures has detrimental effects. Active and passive smoking also causes its own deleterious effects on the already taxed lungs. Such impact is more pronounced in the extremes of ages. All these factors favor a high incidence of respiratory tract infection related morbidity and mortality [12]. This is evident in case of multidrug resistant TB [MDR-TB], extremely drug resistant TB [XDR-TB] and multidrug resistant respiratory tract infections which occur in the community and hospital settings. These infections being air-borne cause rapid and persistent spread. India is emitting one ton of carbon dioxide per capita, when compared to industrialized nations which do emit more than ten tons [13]. Lack of environmental awareness in the society, inaccessibility of ever demanding quality medical care, makes the situation grim. Unlike water and food hygiene, which could be controlled, at least to a certain extent at individual level, air pollution is not easily controlled as it needs a multilevel approach starting from government down to individual level.

WATER-BORNE / FOOD-BORNE INFECTIOUS DISEASES

Global warming has an impact on available water resources. Continued human exploration of water, melting of polar ice reserve and unseasonal rains complicate the issue. Rising sea level also contributes to food/ water borne infections such as cholera and sea food poisoning. Poor water management, pollution by pesticides and industrial waste has lead to scarcity of drinking water, turning a natural resource into a priced commodity. This has caused excessive dependence upon government supply of water which is becoming increasingly difficult. More over the quality of water supplied by private suppliers is not always reliable. Contamination of water lines with sewage and leakage in the water supply system needs to be addressed immediately at a war footing level to reduce wastage of available water [14].

WHO estimates about 97 million Indians lack access to safe drinking water. The World Bank estimates that 21% of communicable diseases in India are related to unsafe water [15]. A warmer climate can cause water-borne diseases more frequently. Diarrheal diseases are already a major cause of morbidity and mortality in South Asia [12]. In this situation it may not be surprising that diarrhea is a leading disease in children aged under five [16].

FOOD AND INFECTIONS

Food related infections are closely linked with food contamination and quality. Food related infections may be due to consumption of contaminated food which manifests as food poisoning. On the contrary, routine consumption of nutritionally deficient food will lead to malnutrition and secondary infections. In a climate compromised situation where access to quality food by the poor is not possible, malnutrition and infections related to them co-exist [17, 18].

Global warming and monsoon deficit reduces agricultural output, qualitatively and quantitatively. Thus supply demand ratio increases leading to food deprivation by vulnerable population such as extremes of age, people living below poverty line, immuno-suppressed patients, people who are displaced due to war, disease outbreaks or natural calamity, this can cause protein energy malnutrition (PEM). Appropriate economic policy is necessary to keep inflation in check. PEM and infections form vicious cycle. Treatment of PEM can reduce the burden of infections which will pave way for a positive health economics.

VECTOR-BORNE INFECTIOUS DISEASES

Studies have revealed the increased transmission rates of vector-borne diseases in the background of the rising sea levels [19]. Climate has an important role in determining the spatial and temporal distribution of vectors and pathogens [20].

Climate change would directly affect disease transmission by shifting the vector's geographic range and increasing reproductive and biting rates and by shortening the pathogen incubation period. Human migration along with decreased access to health infrastructure and projected climate change could contribute to increased disease transmission [21]. Global climate might prolong transmission seasons and risk immunologically naive populations to newer

pathogens [22]. Global burden of dengue has increased fourfold in the last three decades [23]. Studies have predicted that 50-60% of land would become favorable for dengue transmission by the year 2085 [24].

Climate change affects distribution of malaria [25, 26]. Chikungunya has re-emerged since 2005. In India transmission of malaria is likely to be 2-3 months in the Northern and North-eastern states while it may show a decreasing trend in Southern states. On the contrary chikungunya would resurge in south India [27]. National Institute of Malaria and Research [NIMR] studies indicated that Nainital district in Uttarkand state is showing evidence of climate change. Results have shown very high densities of *Anopheles fluviatalis* and presence of *Pl. falciparum* malaria cases in the month of March and April from the hilly parts which did not report malaria earlier.

MEASURES TO IMPROVE THE SITUATION-INDIAN SCENARIO

Air Management

Reduce use of fossil fuel. Switch over to greener technologies like solar powered cooker, vehicles, bicycles use, erecting solar panels. Reduce use of plastics, proper waste disposal including disposal of e-waste. Have kitchen gardens, promote tree planting. Encourage use of public transport system. Avoid vehicles for short distances and maintain vehicles appropriately. Encourage car pooling system and usage of renewable energy driven vehicles. Reduce, at least if not quit smoking in public places. Non-smokers should strictly object to such acts in the public.

Government can implement certain measures to keep the air pollution rate in check. More tax may be levied on people using multiple vehicles. Students can be discouraged from possessing fossil fuel driven vehicles. In case of possession of multiple vehicles students can be made to undergo an additional course on environment science including practical training in case of science stream students and economic aspects of environmental degradation along with a related project in case of arts and commerce stream students. The candidate has to earn prescribed credits which have limited validity. Possession of a stipulated minimum aggregate in environment related courses should be made mandatory for such candidates to earn their degree/diploma. All the streams of education can follow this method. Profession-specific environmental issues should be given due stress and encourage to find solutions to rectify the same.

Provision of quarters near the workplace reduces vehicle use. Government can frame laws restricting admissions to schools and colleges for the people staying at limited distances, so that, usage of vehicles to transport students can be minimized. In case if students are to be admitted from distant places, hostel accommodation can be made compulsory. Employees who live in campus/near campus in the residential quarters should be encouraged to use solar driven vehicles/bi-cycles. People using greener technology, practicing safe environment practices in work places can be considered for increment/ promotion or should be appreciated and rewarded. This can be an inspiration for others to follow in future.

Free power supply will lead to misuse causing environmental damage. Ban the use of tungsten filament bulbs. At least 20% to 30% of energy requirement must be derived from harnessing solar power. Building approval charges by the government for green buildings should be subsidized and non-compliance with this rule can attract higher approval costs and higher taxes. Houses/Factories which use solar / greener/ renewable energy should be given an appropriate subsidy in building taxes.

Regular overhauling of public vehicles to maintain their efficacy, change to greener technologies in a phased manner is necessary. Parking charges and road tax for greener vehicles to be subsidized when compared to fossil fuel driven vehicles. Greener vehicle should cost less than conventional vehicles.

Government can ban use of wood as fuel for cooking. Instead, utilization of solar energy can be encouraged. This approach has two benefits. The first one being we can save trees, which in turn can increase the forest cover there by increasing the chances of rainfall and water harvesting. The second one being, solar cooking does not emit any toxic/noxious gas into the environment. Log wood cooking can cause respiratory illness increasing the morbidity, mortality, economic burden to the affected person and their family. This can be a lifelong problem especially when diseases like asthma and COPD sets in. More over these can exacerbate infections and complicate as cardiac diseases especially with COPD. This can at least partly reduce the burden of asthma and COPD which is becoming common in child hood.

Water Management

Water conservation should start at home. It is our duty to seal all the leaky taps in our houses. Use water judiciously. Rain water harvesting should be done. Encourage tree plantation to improve rainfall. Use low flush toilets in houses to reduce water consumption [28].

Government should frame strict laws to reduce, misuse and wastage of essential drinking water and polluting drinking water sources. Steps are to be taken to effectively use the available water, recycling of water and measures to harness water effectively with least disturbance to the nature. Effective recycling of water and proper sewage disposal in residential areas and apartments which lodge ten or more families can be made compulsory. All the OTS (open to sky) areas of

an apartment complex can be connected to rain water harvesting system. This will enable storage of large quantities of water. Parks in a locality can be used effectively for water harvesting. All these measures will enhance water harvesting and water table level respectively.

Proper sealing of leaking pipe lines will definitely save millions of liters of this essential commodity. Water supplied should be used judiciously and wastage of water should attract a fine. Water table level should be raised by planning community farming which can be a public private partnership where government shall provide lands and private parties to hire man power. This is a beneficial system where water table increases and employment opportunity is provided to the local youth. The required manure for this project can be obtained from solid municipal waste which is easily and readily available and such a project can be executed at panchayat level with the help of NGOs and self help groups.

Harvesting rain water is another measure which requires attention. Proper rainwater harvesting systems should be in force for any approved building and it should be properly utilized for harnessing water. On the contrary maintenance of catchment areas should be under strict government vigilance. Water harvesting bodies in the community should be strictly prohibited from direct human access and only government authorized persons should be allowed to enter them, supervise and execute water management. Catchment areas should not be allowed to be used as dumping yards during dry seasons. Any form of pollution to the water source should be strictly dealt with appropriate laws.

In a country like ours nationalization of rivers and dams shall be implemented. This can be done after providing proper infrastructure for sewage treatment. This obviously has multiple benefits where excess water being drained into sea can be stored in dams for future use. This will be of utmost use in monsoon seasons and to tide over drought season.

Sea water desalinization in those areas where rainfall is scanty and river linking will be exhaustive but can be mooted. Recently the Government of India has taken initiatives to clean up the river Ganges. This is a welcome change and it can be hoped that, all major rivers in the country will be given a similar treatment in the years to come. Citizens also should be aware of the consequences of pollution and they should co-operate to maintain cleanliness of water bodies.

Food Management

Access to quality food in sufficient quantity is an important component in food management. Governments are striving to achieve this goal by promoting agriculture and supplying food at subsidized rates to the needy people. Challenges are many in making both the ends meet. Dwindling agricultural land space and prolonged drought with reduced rainfall makes agriculture the most challenging profession. Prevailing climatic conditions do not favor conventional crops and on the other hand agricultural scientists are forced to develop drought resistant, heat resistant varieties of crops. Scientists are bringing out crops with a less turnaround time so as to fulfill the ever increasing demand for food. Steps to boost agricultural productivity are regularly employed, but post harvest technology is still not picking up in our country. Owing to this we land up in diminished utilization of the crops grown and we lose the yield due to poor storage facilities. Tamil Nadu agricultural university (TNAU) portal on post harvest management quotes as much as 20%-30% loss of vegetables and fruits in Tamilnadu state alone [29].

Infection Management

WHO estimates reveal about 1,50,000 deaths occurring worldwide especially in low income countries owing to climate adversities [30]. South East Asian Region lodges 26% of world's population. It is also the area where about one third of world's poor people reside [31, 32]. Proper sanitation and hygiene are vital in preventing most of the community acquired infections. Habits like open air defecation, misuse of water bodies dedicated for drinking purposes should be banned. Personal hygiene should be stressed to every citizen and should be encouraged to practice from school level.

Antibiotic usage is rampant and in a country like ours in most of the cases there is no substantiation to start or change over or to stop an antibiotic. The rationale behind antibiotic use is totally lacking both in the professional level and in the community level.

Prudent and judicious use of antibiotics should be deligently followed. Prescribing doctors should strictly follow antibiotic practices and the government along with bodies like NGO, Indian Medical Association (IMA) can formulate local antibiotic policies. Empirical therapy should be formulated for specific etiological/ clinical setting and subsequent specific antibiotic therapy should be based on culture and sensitivity report. Laboratories performing these tests should be made to participate in quality control programs. This should be made mandatory for renewal of their periodical licensing and such culture/ sensitivity reports should be supervised, signed by a qualified medical microbiologist only. Thus, the right drug for right duration at correct dosage should be given to the appropriate patient. All these efforts can reduce the menace of antibiotic resistance at least to a certain extent. Cycling of antibiotics is another mechanism which can combat infections more effectively. Unfortunately, in a country like ours where infectious diseases are very common we have only a handful of

dedicated infectious disease consultants and they are positioned in urban settings. Access to these consultants by rural patients and practitioners is difficult. Ideally more specialists in this branch are to be made available and specialized infectious disease clinics should be conducted at all strata of government health care system. Over the counter sale of antibiotics should be banned and strict antibiotic stewardship to be practiced at individual practitioner level and community level. Public should be made aware of the ill effects of irrational use of antibiotics and the price they are going to pay in future if they do not adhere to medical advice strictly. Medical colleges in the nearby vicinity can be roped in to formulate antibiotic policy of the concerned locality. All antibiotic prescriptions must be documented and submitted to health ministry on demand for auditing both at the practitioner level and pharmacist level. Any deviation from antibiotic guidelines should be scientifically substantiated by the prescribing doctor/pharmacist, failing which disciplinary action may be initiated. Local watch bodies may be organized to make this program more effective. Simultaneously environmental sanitation along with prophylactic measures need to be followed to reduce the burden of infectious diseases. To achieve this, self help groups [SHG] and NGOs can be utilized to sensitize the public. Effectively functioning SHG/NGO can be rewarded either monetarily or otherwise. Government should make an initiative to formulate an appropriate infection control practice which can be easily practiced. Further those programs can be monitored by health agencies and pollution control boards. Regular updating and validation of antibiotic policy and infection control practices should be done. Hospital/ clinics/laboratories/ diagnostic centers should be made to adhere to these guidelines strictly. We have successfully formulated guidelines to tackle antibiotic resistance in our country [33]. Time has finally come to implement these guidelines to combat the antibiotic resistance menace. Moreover literature is available regarding use of antibiotics in poultry industry and its share of resistance to antibiotics. So, simultaneous action by medical and poultry scientists is needed to overcome the problem.

Health Economics

The GDP of a country depends on the quality of work force it has. A higher GDP is possible only when economic policies are sound and viable with adequate focus on short term and long term goals. These targets can be achieved only with a strong and a healthy work force by reducing sickness absenteeism. A healthy work force can be achieved only when environment [physical and mental] is given its due care. In a stressed environment with pollution, water scarcity, unhygienic surroundings, the chances of health costs for self and dependents is likely to escalate. This will have an impact on economic growth in terms of production as well as spending nature of the person. World Bank report quotes that, 21% of GDP in India is obtained from agricultural productivity. Environment stress such as diminished water reserve, unseasonal rains, heat waves, cyclones all have a direct impact on agriculture. A society spending more on preventive aspects of diseases is always doing better than a society which is devoting most of its monetary resources on curative aspects of preventable diseases. With the current scenario of deteriorating environmental hygiene there is emergence of newer diseases and re-emergence of dormant diseases including infectious diseases. Thus a safe and clean environment will lead to better work output, higher GDP and better standards of living [7]. Better standards of living should be uniform throughout the country and there should not be much difference between urban and rural setting. This is vital, as it will reduce the brain drain to the so called developed countries and also prevent migration of labor force out of the country. Longevity of life has considerably increased but not the quality. Longevity with quality should be the goal to achieve the WHO standards of holistic health. Humans are conquering some diseases, controlling certain diseases, modifying some diseases but all these can be sustained and progressed further only with the availability of safer, greener and cleaner environment.

Various competitive exams and interviews conducted by government and private bodies should lay stress on environment related issues pertaining to their fraternity. Department exams should also follow similar guidelines. Safe environmental practices should be stressed at various strata of the society. Government can conduct exhibitions in this regard and can encourage entrepreneurs on similar line. Talent awards can be created for solutions formulated regarding environment issues. T.V. channels and other popular media can be roped in to display safe environmental practices during their prime time. This could achieve a wider coverage and better reach to the community. Saving the environment is saving ourselves.

Changing climatic conditions are posing an imminent danger of anthropogenic mass extinction. Climate changes have adversely affected quality of air, water, food and have increased the risk of infections in man including vector-borne diseases. Measures to tackle climate change should start from individual level from our homes and enough Govt support is required. There is an urgent need to address this problem to reduce the burden of increasing human infections.

CONCLUSION

Climate changes, induced by human activities have been predisposing man to several infectious diseases both new and old. Measures to check global warming, to reduce undesirable changes in air, water, food, etc are imminent and should be taken at all levels from individual level to Govt policy level.

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