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Environmental Health Monitoring: A Risk Factor Approach towards Health

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Abstract:
Health has always gained importance during a disease outbreak. With rapid urbanization, lifestyle based (non-communicable) diseases have started taking a toll on the health of developed, developing and under-developed nations. Infectious diseases (vector borne, water borne) are still prevalent in developing and under-developed nations which is one of the main hindrances to enhancement of life expectancies. The recognition of the role of the physical/natural environment on health that led to the elimination of infectious (communicable) diseases in the west, (as early as the 1960s), has failed to make a similar impact on India (which can be considered representative of other rapidly developing nations). Further, due to transition in causes of mortality and extensive research to explore risk factors of non-communicable diseases, the scope of environment, as a health determinant has also expanded with the addition of other community attributes like socio-economic, cultural, and political environments. This is of significance not only because it goes on to show the complex nature of NCD epidemiology but also because the double burden of communicable and non-communicable diseases can seriously challenge a nation's economic growth and its resources during an outbreak. Thus, this paper aims to establish a rationale for development of an environmental health monitoring system that would monitor risk factors for both communicable and non-communicable diseases.

Keywords: *Environmental health monitoring, risk factors*

1. Introduction

Throughout human history, the major problems of health that humanity has faced have been concerned with community life, example, the control of transmissible disease, improvement of the physical environment, i.e. sanitation, provision of water and food of good quality and of adequate and equitable medical care and relief of disability and destitution (Rosen, G. 1993). The World Health Organization has defined environmental health as "physical, chemical and biological factors and related factors impacting behaviors". However, with progressive research in the field of health, especially in developed nations, to understand the complexity of etiology and prevalence of noncommunicable diseases (Chaix et al., 2011; Yusuf et al., 2004; Pickett & Pearl, 2001; Diez-Roux et al., 1999; Krieger et al., 2005; Ebrahim et al., 2004) a gamut of other factors have been added to the context of the environment related diseases. This includes economic, social, political and cultural environments (Krieger et al., 2005). Prior to the germ theory era, that began in 1860, it was the natural tendency of people to attribute the cause of any disease to various components of the natural environment, mainly air and water and sometimes humans (e.g. lepers were ostracized from society as etiology of leprosy, a fatal infectious disease was not known).However, the impact the germ theory had, especially on medical scientists and professionals shifted the emphasis on microorganisms that caused the diseases. It was realized that newer scientific insights led to deeper understanding and more rapid cure (Rosen, 1993). Together with other breakthroughs, in the fields of vaccination, surgery and public health interventions the western nations (United Kingdom & United States of America) were able to successfully decrease and even eradicate almost all communicable diseases (e.g. cholera, typhoid, syphilis, diphtheria etc.) by the 1960s. Thus reduction of mortality in Europe and other Western countries during the 19th century was determined primarily by eco-biological and socio-economical factors as medical factors were largely inadvertent until the 20th century by which time the pandemics of infection like syphilis, cholera and diphtheria had receded. On the contrary, in developing countries the mortality decline was directly determined by medical factors, due to the tremendous impact of imported medical technologies (Omran, 1971) due to which risk factors for communicable diseases still remain. With communicable diseases under control, life expectancies around the world started increasing. Increase in life expectancies led to the onset of degenerative diseases like cardiovascular diseases, diabetes, chronic Obstructive Pulmonary Disease (COPD) along with increases in rates of urbanization. Japan is the first non-European nation to have made the transition from cause of death dominated by infectious diseases to one dominated by degenerative diseases (Johannson & Mosk, 1987). The life expectancy of Japan stands at 84.74 years compared to 81.50 years in United Kingdom (World Bank), when 115 years ago (in 1900s) both UK and Japan had similar life expectancies of 40 years (Johannson & Mosk, 1987). This was achieved not only due to interventions in the public health sector but also interventions in the field of education along with other factors like natural protection (Japan unlike UK was predominantly a rural economy and depended more on its human manpower than natural resources, unlike U.K. which was undergoing rapid urbanization due to the industrial revolution. Among developing countries, China & India, both of which are rapidly growing economies and highly populated, a significant difference lies in their life expectancies. China with 75.20 years and India with 66.21 years (World Bank). Both are developing nations having very high populations with GDP per capita of China more than India (World Bank). Infant mortality is higher in India due to presence of infectious and parasitic diseases unlike China where the most common cause of death is cancer (Dummer & Cook, 2008). This high life expectancy in China can also be attributed to factors like, higher number of physicians & hospitals per head in China than India (Dummer & Cook, 2008) and the recognition of importance of preventive medicine over therapeutic medicine as early as 1950 (Hezketh & Zhu, 1997) compared to 1983 in India (MoHFW, 1983). Thus, mortality is as complex as the biological, political, economic and cultural forces that drive it and there is no simple single determinant (Johannson & Mosk, 1987). In spite of advanced medical interventions and extensive research in the field of infectious diseases 3 out of 10 globally still deaths are due to communicable diseases globally. Cardiovascular diseases are a leading cause of death in the world (58.3%) followed by infectious and parasitic diseases (32.3%) and cancers and other diseases (World Health Organization, 2009). Thus, focus on research has also shifted from communicable to non-communicable diseases in India when infections due to water and vector borne diseases are still one of the major causes of morbidity and mortality.

1.1. Germ theory & Health in U.K. & India

Even though the concept of environmental health is relatively new it formed the central theme of the treatise Airs, Waters & Places written by Hippocrates (a Greek physician) one of the famous excerpts of which said “Whoever wishes to investigate medicine properly, should proceed thus in the first place to consider the seasons of the year,…………. the winds, the hot and the cold………, qualities of the waters.” (Adams & others, 1929). Greek medicine never relied on curative but believed in preventive measures that would prevent physical factors of the environment from causing effects on the human body (Rosen, 1910). Prior to the germ theory era, life expectancy was low with causes of death being infectious diseases (Lederberg, 2000). Epidemics such as the major Black Plague during the Middle Ages (500AD-1500AD), leprosy, and syphilis led to expulsion of diseased individuals from the society in order to protect the unaffected population due to ignorance of the etiology of these diseases. Thus, to protect the health of the ‘unaffected population’ the ’affected population’ was deprived of their civil rights (e.g. ostracization of lepers) (Rosen, G. 1958). Cholera was another highly infectious disease which was mainly known for the rapidity of its spread and consequent deaths (Snow, 1988). The cholera epidemic of 1854 led Dr. John Snow to come to a conclusion that it is a water borne disease ‘the causal agent must enter by mouth, multiply within the gut that spread to others by the fecal oral route’ that was contradictory to the popular belief that cholera was caused due to miasma or bad air (Brody, et al., 2000). When he plotted the number of deaths from cholera on a map he found a cluster of cases around the ‘Broad Street Pump’ from where most of the deceased had drunk water. He thus came to the conclusion that it could well have been the reason for the outbreak of the epidemic. The dismantling of the pump led to the drastic decrease in mortality. The industrial revolution also played an important role in bringing to fore the problem of public health. Characterized by rapid population growth out-pacing availability of housing led to a rise in mortality rates due to rapid spread of infection as people were living in crowded conditions. In London, between 1800 and 1840 the population was around two million residents (Bynum & Porter, 1991). It was due to the efforts of Edwin Chadwick in 1848 that ‘filth’ was officially recognized as ‘man’s greatest enemy’ and after much harping on the fact that the lifestyle in which the ‘laboring population’ lived facilitated transmission of diseases led to the implementation of Public Health Act of 1848 (Fee & Brown, 2005). Chadwick described the prevalence of diseases among the laborer population showing that the poor exhibited a pre-ponderance of disease and disability compared to more affluent populations. The germ theory era started shortly after the proof of Snow’s hypothesis that cholera is a water borne disease, with discovery of microorganisms for various infections. The era was not only characterized by discovery of microorganisms but also improvements in the field of surgery (discovery of sterilization property of alcohol and anesthesia), sanitary interventions and immunology (Rosen, 1993). These discoveries led to important insights into vectors with respect to transmission of diseases. This led to a decrease in the number of cases of various diseases like typhoid, syphilis, diphtheria, typhus. For example, by 1940 the causes of deaths in children attributed to diphtheria was brought down to 1.1 per 100000 compared to 785 per 100000 in 1894 which was due to identification of the microorganisms and mass immunization. However, an important point to be noted is that the sanitary movement like slum clearances, improvements in cleanliness, introduction of proper sewerage systems and water supplies, isolation of carriers, vaccination together led to the drastic decrease in the death rate of both typhoid and paratyphoid fevers to 0.2 per 100000 person by 1947. Syphilis was brought under control from 18 to 8 per 100000 in 1948 by carrying out blood tests for couples, mass screening surveys and health education campaigns (Rosen G., 1993). After 1870 life expectancies increased from 40 years in 1820 to 50 years in the first decade of the 20th century (Cutler et al., 2006) .With control of infectious diseases, ‘modern’ diseases like cancer, diabetes, cardiovascular diseases and mental illnesses started coming into prominence in these industrialized countries for which the causes could not be explained on the basis of the germ theory. Thus came to fore the theory of ‘multifactorial causation’. This concept was first brought to light by Pettenkoffer of Munich (1819-1910). However, he did not get much attention during the germ theory era (Park, 2007) and only gained importance after lifestyle based/non-communicable diseases started increasing.

In India, poverty has always been the main issue as far as health was/is concerned. However, problems of poverty and associated questions on health and disease were predominantly issues of rural society as only 10% of India’s population was classified as urban, in the 19th century (Arnold, 2012). Three main diseases that wreaked havoc in colonial India (India was under British rule from 1747 to 1947) were cholera, malaria and plague all of which rose from the unhygienic conditions that were present in the country. Cholera occurred due to the absence of proper water supply and unhygienic living conditions. Plague was due to abundance of rats in close proximity to human habitation. Malaria was related to the presence of water pooling or marshy areas. Between 1892 and 1940, over ten million people died of plague in India and over 15 million died of cholera. Affected people were considered risks, thus, quarantinism was the most common strategy used to control epidemics, like plague. However, it was soon realized that it interfered with trade (Polu, 2012). This led to other means of controlling the epidemic. This included house to house search for plague infected individuals, taking people out of plague infected dwellings, destroying plague infected materials, disregarding any cultural and religious sentiments, setting up of leper asylums where forcible segregation of patients was carried out (Mushtaq, 2009) and banning of overcrowded pilgrimages (Arnold, 1993). The epidemiological risks that plague and cholera posed to Europe and the economic and political risks that not containing the epidemics posed to India fundamentally shaped the Government of India's policy responses to the plague and cholera epidemics of the 1890s (Polu, 2012). Implementation of disease interventions such as quarantinisms and policies were influenced by factors like trade, economy, war and pilgrimages with the main aim being to prevent endemic diseases from becoming epidemic. Malaria was another disease that affected 100 million Indians annually (Polu, 2012). Even though it was primarily considered to be a rural disease the causes were man made, like improper drainage issues due to construction works that provided breeding grounds for mosquitoes. Unlike cholera and plague, malaria was not a threat to international trade because of two main reasons. Firstly it did not spread by direct contact between a malarious and a non-malarious person and secondly malaria was a disease more specific to India due to the climatic conditions that are prevalent for mosquito breeding and the parasite. The only means by which it hampered the economic status was that it took a toll on the health of laborers who lived in poor conditions. The discovery of quinine as having anti-malarial properties made the government of India prioritize quinine production rather than eliminating mosquito breeding grounds (Polu 2012). Sir Ronald Ross who discovered mosquitoes as the carrier of malarial parasite also advocated that quinine prophylaxis can be effective coupled with elimination of mosquito breeding grounds, use of mosquito nets and wire gauze protection of houses which can eliminate malaria along with quinine prophylaxis. The bacteriological era that led to advances in understandings of disease changed the public health interventions as the discovery of etiology of plague diverted the focus from human policing to elimination of rats (Polu, 2012). The western world completed its public health revolution before the introduction of antibiotics by eliminating infectious diseases through public health measures whereas in India much of the efforts of the champions of public health ended up by creating provisions of curative services (Jacob, 2007). Even after milestone discoveries that led to eradication of infectious diseases in the west India was still dealing with epidemics like a major plague pandemic from 1898 to 1908 that caused around 500,000 deaths but subsided in 1940 only to resurface in 1994. Leprosy cases dropped by 80% in 1996 due to introduction of multi-drug therapy but is still not eliminated. Similar is the status for diarrheal and vector borne diseases which still form a considerable part of the morbidity burden in India (Gupte, et al. 2001). Water borne diseases like diarrhea are still common due to contaminated drinking water and insanitary behavioral practices. However, due to its short duration it does not get reported. Vector borne diseases also follow seasonal trends with monsoon and post monsoon being followed by high incidences of malaria, dengue and chikungunya. Further, new and emerging diseases like swine flu has also been added to the list of infectious diseases.

2. Risk Factors & the Risk Transition

The epidemiological transition theory by Abdel Omran is one of the most well-known and accepted health transition framework that has described a shift in causes of death from infectious, communicable or acute diseases such as measles, malaria and diarrhea to non-infectious, non-communicable or chronic diseases such as cancer, heart disease and stroke due to changes in health characteristics preceding and during demographic transition (Smith & Ezzati, 2005). However, for a transition of mortality to take place it needs to be preceded by a transition in the nature of risks that facilitate disease causation and consequently mortality. The World Health Organisation defines a risk factor as 'any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease or injury' and can be modified by intervention thereby reducing the probability of disease or other specified outcomes (Last, 2001). It is not necessarily a causal factor (Kindig, 2007). A causal factor or a cause can be defined as 'an antecedent event, condition, or characteristic that preceded the disease event and without which the disease event either would not have occurred at all or would not have occurred until some later time.' (Rothman and Greenland, 1998). In the pre germ-theory era sanitation and hygiene were the most important risk factors which were eliminated in the west and mortality decreased but those risk factors still remain today in developing and underdeveloped nations and is one of the main determining factors for increases in life expectancies. Simultaneously, with onset of NCDs the nature of health risk factors are becoming more heterogeneous in India. The property of risk factors for communicable and non-communicable diseases differ in the time (the lag period), that it takes for the disease causation to lead to a disease. For a communicable disease like diarrhea, change in diseases might come quickly upon changes in the risk factor (e.g., reduction in diarrheal diseases from better sanitation/water) whereas, in other cases, the shift in risk factor may come years or decades before the change in disease incidence, for example, cancer from smoking (Smith & Ezzati, 2005). Likewise it is easy to eliminate risk factors of a communicable disease by public health interventions (cholera), vaccinations (for smallpox, polio) whereas risk factors of that of non-communicable diseases are complex to handle and their identification is very important as the onset of the disease can take place many years later. The Global Health Risk report by WHO mentions of underweight, unsafe sex, high blood pressure, tobacco and alcohol consumption, and unsafe water, sanitation and hygiene. Health risks are in transition with populations ageing owing to successes against infectious diseases with patterns of physical activity and food, alcohol and tobacco consumption changing simultaneously (WHO 2009).

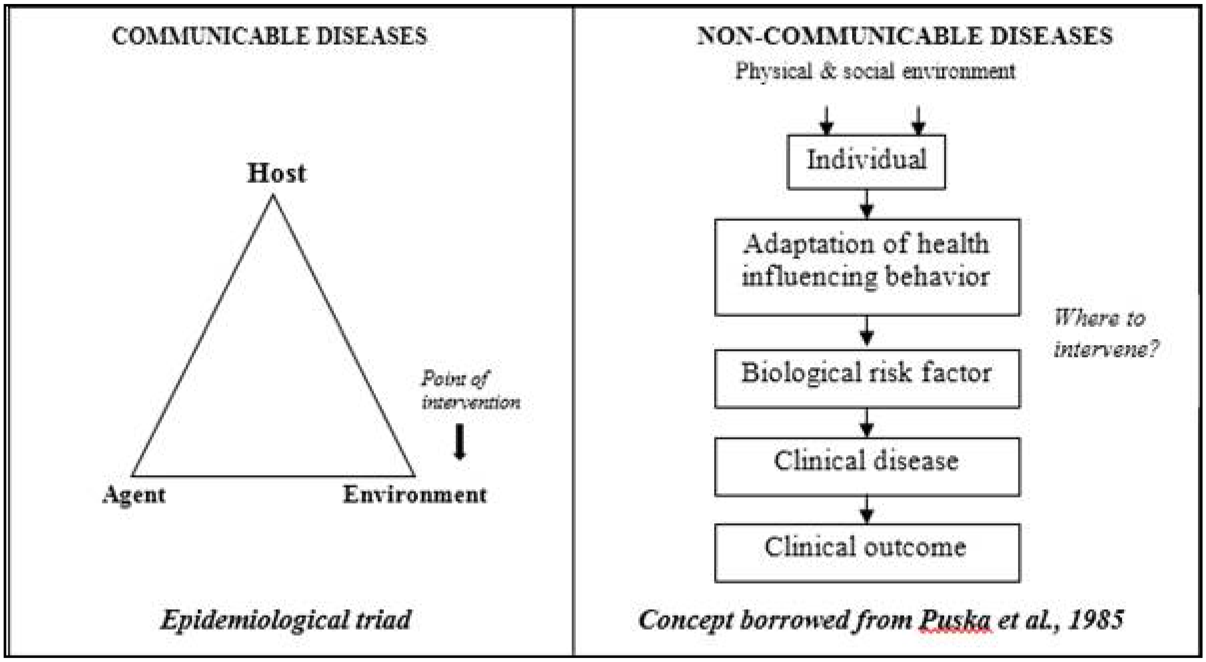

Figure 1: Differences in risk factors between communicable and non- communicable diseases

3. Risk Factors in Context to Urbanization

Urbanization is a major public health challenge for the 21st century as populations are increasing rapidly, basic infrastructure is insufficient and social and economic aspects in urban areas result in significant inequities (Kjellstorm & Mercado, 2008). The earliest signs of urbanization was seen in the era of the industrial revolution. Congested dwellings and poor working conditions in the factories provided favorable conditions for diseases such as typhus, to spread (Rosen, G. 1993). The rates of urbanization have increased globally from 36% of the world population living in urban areas in 1970 to 44.8% in 1994 and this is projected to increase to 61.1% by 2025 (Yusuf et al., 2004). It is also predicted that most of the growth will occur in less wealthy nations of the world i.e. from 1.9 billion in 2000 to 3.9 billion in 2030 with Asia and Africa being the most rapidly growing populations worldwide (Vlahov & Galea, 2003). The close proximity of people is a prominent urban factor. The world's densest cities are in Asia, with Mumbai having 30, 000 inhabitants per km². (Aliroll, 2011). Urbanization is not only accompanied by increase in population (due to immigration from rural areas), but also degradation of the physical environment which facilitates the expansion of a prospective city (Jorgenson, 2004, Vlahov & Galea, 2003, Dewan et al., 2012). This degradation can be in the form of deterioration in air quality, water quality, improper solid waste management and an increase of low socio-economic settlements called slums or urban sprawls, which is the most conspicuous consequence of urbanization in developing countries. Risks to health are widely distributed in the population, with individuals differing in the extent of risk rather than whether they are at risk or not. Individuals living in the same environment (in an urban scenario) are not affected by the environment in the same way, neither do they sustain health risks similar to one another (Taylor & Repetti, 1997). This is an instance of relative deprivation which is described as a problem arising not only because of disparities in income but also disparity of their situations. Thus an individual of relatively poor health in one community might at the same income level be the richest people in another community (Syme, 1998). Social inequality extends beyond differences in jobs, earnings, prestige, and power, to the consequences of this inequality for individual well-being (Ross & Wu, 1995). Differences in attainment of level of education also leads to consequences of social inequality as it determines the working conditions, income, adaptation of risk behaviors (e.g. smoking and drinking) and awareness of self-health which can lead to a negative impact on health (Ross & Wu, 1995). This leads to differences in coping stress as well. Stress produces cumulative identifiable damage that results in increased pathology (Seeman et al., 1996). Negative emotions like depression, anxiety and anger are risk factors for cardiac events. On the other hand they play a significant role in health risks, including all-cause mortality. Coping strategy i.e. dealing with the health anomaly, is another very important factor which differs among individuals living in different social environments. Individuals who find constructive ways of coping with stress such as taking direct action or finding meaning in their experiences may be better able to withstand the potential adverse effects of stressful circumstances (Taylor & Repetti 2009). A low awareness of one's health symptoms may lead to a disease for e.g. an NCD may progress and develop severe, near end stage complications (Riley et al., 2007). For example, the presence of middle socio economic status neighbors appear to have a protective effect in reducing aggression and delinquency among low socio-economic status youngsters, but it may simultaneously adversely affect the ability to develop social relationships with their peers (Kupersmidt et al., 1995). Similarly, health behaviors, diet and nutrition, unemployment can also become risk factors for health especially in an urban scenario because income disparities can lead to disparities of other factors like education or vice versa which may lead to differences in coping mechanisms. Thus urbanization, besides introducing health risk factors in the physical environment like air pollution, vectors, and solid waste (exogenous) also leads to differences in their impact as far as the target group is concerned by virtue of the disparities in income, education, diet, habits etc. These effects are more likely to be seen in developing countries where the consequences of urbanization are more evident and the low socio-economic group is more susceptible compared to developed countries where urbanization has already taken place.

4. Population health & Environmental Health

In the late 1960s when infectious diseases were almost eliminated from the western nations the role of the physical environment as a health determinant was thrown in to oblivion until non-communicable diseases started gaining prominence. It was Pettenkoffer of Munich who brought up the theory of “multifactorial causation” of diseases. Since then it was realized that diseases can be caused not only due to environmental elements but also due to individual attributes which include behavioral factors like risk behaviors, hygiene and sanitation practised by individuals living in a particular area. There is a dynamic relationship between people and the environment and each influences the other (Cohen et al., 2000). The external environment can no longer be studied in isolation as the sole determinant of health, without studying the compositional characteristics of individuals inhabiting it i.e. the collective health of the population. Population health is defined as ‘health status indicators as influenced by social, economic and physical environments, personal health practices, individual capacity and coping skills, human biology and health services in a group’ (Dunn & Hayes, 1999). Thus, there is a need to analyze both individual (compositional) and macro/environmental level (contextual) risk factors and outcomes (Malmstrom et al., 1999). This multilevel or contextual analyses of social factors and health represent a possible reconciliation between two divergent epidemiologic perspectives – individual risk factor epidemiology and an ecological approach. (Pickett & Pearl 2001). The Framingham Heart Study that started in 1948 set the path for prospective population studies (mainly for noncommunicable diseases). The study identified major risk factors like high blood pressure, high blood cholesterol, smoking, obesity, diabetes, and physical inactivity **-** as well as a great deal of valuable information on the effects of related factors such as blood triglyceride and HDL cholesterol levels, age, gender, and psychosocial issues (Framingham Heart Study website). In spite of the nature of risk factors identified, being majorly physiological they became the point of departure for many other studies conducted in different countries e.g. ARIC Study (Diez-Roux et al., 1999), Whitehall Study (Smith et al., 1990), RECORD study (Chaix et al., 2011), Shimane COHRE study (Hamano et al., 2012)**,** CARMELA (Schargrodsky et al., 2008), INTERHEART (Yusuf et al., 2004) , North Karelia (Puska et al., 1985), SHARE (Anand et al., 2000)), CUPS Study (Premalatha et al., 2000). Since cardiovascular diseases are the highest cause of mortality the main focus of risk factor studies have been on this aspect in developed nations (Zhou et al., 2002, Diez-Roux et al., 1999, Babisch et al., 2005, Samet et.al 2000, Nuvolone et al., 2011, Ebrahim et al., 2004, Joseph et al., 2003, Puska et al., 2002, Winkleby et al, 1992, Alves et al, 2004). Overweight, smoking low BMI, high blood pressure, low physical activity, diet, air pollution, diurnal temperature, income, educational status have been identified as determinants of cardiovascular diseases. Comparatively, such studies are less in a developing country like India (Sugathan et al., 2008; Gupta et al., 1994, Allender et al., 2010; Singh et al., 2011, Premalatha et al., 2000, Thankappan et al., 2010, Gupta et al., 1994, Mohan et al., 2001) and are cross-sectional and non-exploratory in nature**.** Knowledge of most risk factors for non-communicable diseases in developing countries is derived from developed countries (Yusuf et al., 2004) in-spite of there being differences in prevalence and nature of risk factors between developed & developing countries (Pereira et al., 2009) which lead to gross inequality in health (Marmot, 2005). Due to predominance of non-communicable diseases the role of the physical environment has been highly neglected in developing nations where morbidity from infectious diseases still exist. Communicable diseases studies are carried out only after an outbreak (Dhingra et al., 2010, Thangaratham et al., 2006, Chakravarti & Kumaria, 2005, Kochar et al., 2009). Thus, there is a need to merge population and environmental studies in developing countries due to the presence of both non-communicable and communicable diseases respectively.

5. Need for an Environmental Health Monitoring System in India

Transition of causes of mortality is preceded by transition of their risk factors. In developing and under-developed countries the epidemiological transition has not yet traversed its full path. Incidence of infectious diseases like malaria, dengue, chikungunya, typhoid, swine flu etc. is an indication of the presence of their risk factors. Thus, a large part of the underlying cause of disease, injury and death in developing countries lie outside the scope of the healthcare system and include physical factors like inadequate sanitation, polluted water, drainage, lack of waste removal, inadequate housing and irregular poor household energy which may turn into public health problems (Listorti & Doumani, 2001). This can pose serious challenges in the event of an epidemic outbreak of a new disease like swine flu, which claimed many lives during its first incidence in India in 2009 and has since then developed a seasonal trend in the country. With presence of risk factors of other infectious diseases it may further exacerbate the situation as some risk factors may be common. Further by 2020 in developing countries NCDs will account for 69% of all deaths with CVDs in the lead (Allender et al., 2010). Present literature on risk factors are mostly on non-communicable diseases carried out in developed countries which have totally eliminated risk factors for communicable diseases. Thus, the progress of research of non-communicable diseases etiology is not only leading to exploration of a gamut of other risk factors related to social, physical, cultural environment and psychosocial factors but also bringing to fore the complicated nature of causation for non-communicable diseases. Thus, to address both the concerns posed by communicable and non-communicable diseases an environmental health monitoring system addressing both types of risk should be designed. Its objective would be to routinely monitor risk factors (i.e. individual and neighborhood) at routine intervals. This monitoring can be carried out with the help of household surveys and at the same time observing the environment of the particular household being interviewed for the presence/absence of risk factors like water barrels (risk factor for vector borne diseases), housing, sanitation (private/common), solid waste management and scores can be assigned for presence and absence of these determinants. Population and the environment thus can be studied simultaneously, but with a separate approach given to each. Surveillance system like the Integrated Disease Surveillance Programme exists, but it monitors the incidence of 21 infectious diseases and not their risk factors and no routine systematic monitoring is present for non-communicable diseases (like Framingham and North Karelia). Also, most of the literature on infectious diseases are studies carried out only after an outbreak. Secondly, exploratory and longitudinal studies are needed to be carried out to detect new health linkages as the social structure in this country is very different with presence of two starkly different socio-economic groups, one representing extreme poverty and the other representing affluence, a scenario, which is absent in developed nations. This gives rise to extreme differences in diet, occupation, status of educational attainment and most importantly, living environments and possible synergistic effects of both the living environment and individual attributes as NCDs are no longer considered a disease of the affluent class.

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