

## Environmental Health Monitoring for India: An Emerging Nation

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### Abstract

To address the issue of the double burden of disease in India, which includes morbidity from communicable and non-communicable diseases (CDs and NCDs), this study has drawn a framework for an environmental health monitoring system. This system will monitor health risks of both the physical and social environments. 1451 individuals from lower and 1274 from higher socio-economic groups from Pune city were interviewed. Data on self-reported morbidity of CDs (water borne, vector borne and acute respiratory diseases) and NCDs (diabetes, hypertension, cardiovascular, chronic respiratory disease and cancer) were collected. Information on risk factors related to one's socio-economic characteristics (*individual attributes like age, education, risk habits e.g. tobacco chewing, diet, mode of transport and employment status*) and those present in one's physical environment (*presence or absence of a community sanitation, water pooling habitats*) were gathered with the help of a questionnaire and an observational form respectively. Relative risk was calculated to detect the presence of any kind of association between the disease reported and it's a risk factor. An ecological approach towards monitoring of both these kinds of risk factors is suggested, as elimination of these from the individual as well as from the environment is complex (as revealed from the lack of association between certain well established risk factors with the disease that they are known to cause). Acknowledgement of not only the dynamic relationship between humans and their environments but also differentiation of this relationship into different levels are pre-conditions to focused and effective interventions.

**Keywords:** environmental health, monitoring, India, ecological model

## Introduction

World renowned economist Amartya Sen in the year 2013 has very aptly described the situation in India in his book, *An uncertain glory: India and its contradictions* along with notable economist Jean Dreze, in the sentence “...unequal patterns of development are making the country look more and more like islands of California in a sea of sub-Saharan Africa.” This description makes one envision a scenario of disparity that is visually evident because it describes the stark socio-environmental differences, a dominant characteristic in this nation. “...islands of California in a sea of Sub-Saharan Africa” can be translated into ‘poverty in juxtaposition with affluence.’ Poverty is a condition that invariably conjures a picture of not only under-nourished and malnourished individuals due to their poor socio-economic status but also that of a degraded environment. A person’s socio-economic status is usually indicated by two major indicators: education & occupation (Razzaque, Mustafa, Ahsan, Islam and Yunus, 2011; Winkleby, Jatulis, Frank and Fortmann, 1992). Especially in an urban area, if an individual does not have basic education, she will be restricted to a limited number of occupations in the latter part of her life. Whatever job she takes up may not provide a satisfactory work environment or a source of income, thereby affecting her health in a direct or indirect way respectively. Financial insecurity does not allow an individual to look beyond her immediate needs which most of the times are basic materialistic goods. Preserving the environment to prevent a disease is therefore not on the agenda of the financially unsound and under-privileged. This leads to activities or actions that are environmentally degrading which in turn affects the health of humans. Thus, both humans and their environments have a dynamic relationship and each influences the other (Cohen, Spear, Schribner, Kissinger, Mason and Wildgen, 2000).

As of April 2016 the World Health Organization website described environmental health as

- All physical, chemical and biological factors external to a person
- All factors related to the factors above, and impact behavior
- Assessment and control of those environmental factors that can potentially affect health
- Prevention of disease and creating health supportive environments

It specifically excludes the following from the definition

- Behavior not related to the environment
- Behavior related to the social and cultural environment and genetics (World Health Organization official website, accessed on April 2016)

The definition clearly differentiates between two behavior types, one that is driven by the non-living environmental (physical and chemical) and biological characteristics and, another due to one’s social/cultural characteristics (the latter are excluded from the definition). When behavioral action is a result of an environmental consequence e.g. drinking contaminated water due to absence of a clean water source (Dutta & Bharucha, 2016), it is an instance of an ‘action required by situational demands’, which shows that the environment is the source which requires the necessary corrective action (Barker, 1968). This perspective on human environment interface highlights the fit of the person to the environment which is an essential, but one sided facet of the interface (Kaplan, 1983). If, in the same instance the individuals are made aware of these preventable diseases that arise from drinking contaminated water and are empowered to take steps to purify it or look for an alternative source this would avert the disease incident. This is an

example of how the inherent behavioral attribute driven by the environmental consequences leads to the prevention of the disease, thereby delegating the role of the environment to human action, as the determinant of health unlike the first case (Dutta & Bharucha, 2016). The WHO definition includes only the environment as the sole determinant in modifying human behavior that affects health and not vice-versa i.e. human behavior also affects the environment and both influence each other.

From an economic stagnation during the colonial period (over 65 years back) to becoming the fastest growing nation in the world (growth rate of 7.3% by the end of 2015), India can be rightly called an emerging nation (Dreze and Sen, 2013 and Khan, 2016). This development has also been an outcome of a significant improvement in life expectancy brought about by lowering of mortality from infectious diseases like cholera, malaria, typhoid and plague in the colonial period of the nation (Polu, 2012). Even though infectious diseases have drastically lowered but they still contribute to about 24.1% of the total disease burden along with rise of non-communicable diseases that contribute to 39.1 % (MoHFW, 2015). The presence of both these disease typologies pose immense challenge to the public health system as their risks are diverse. With progress in research in the field of non-communicable diseases (Chaix, Kestens, Bean, Leal, Karusisi and Meghiref, 2011; Yusuf, Hawken, Ôunpuu, Dans and Avezum, 2004; Pickett & Pearl, 2001; Diez Roux, Nieto, Caulfield, Tyroler, Watson and Szklo, 1999; Krieger, Chen, Waterman, Rehkopf and Subramanian, 2005; Ebrahim, Montaner and Lawler, 2004) the scope of environment has also expanded with a gamut of other factors being added to the context of the environment related diseases which includes social, political and cultural environments (Krieger et al., 2005).

#### Evolution of the concept of environmental health

Today, environmental health is identified as a term having its own definition, but such was not the case before. Ignorance of disease etiology led people to attribute their causes to various components of one's environment. The earliest records that mentions of the role of environment on human health could be found in Hippocrates' treatise "Airs, Waters & Places" written in the 4<sup>th</sup> century B.C. the most popular excerpt from which says that:

*"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 water"* (Adams & others, 1929).

Over the years, outbreaks of fatal diseases brought about enlightenment of disease causation. Before the germ theory era (started in 1860s with discovery of infectious microorganisms) when diseases like cholera, leprosy, plague, syphilis claimed large number of lives in a very short span of time, it was due to lack of knowledge of the causative agents that led people to attribute the cause of the disease to components of one's surroundings like air, water, meteorological conditions etc. (Rosen, 1993). This lack of knowledge of the real etiological agent not only claimed many lives but also saw deprivation of human rights (e.g. ostracisation of lepers) (Rosen, G. 1958). It was due to breakthrough discoveries by eminent scientists like Robert Koch and Louis Pasteur in the field of microbiology that causes of diseases can now be pin-pointed to a specific agent and interventions could be focused on those, leading to their elimination. Together with other breakthroughs, in the fields of vaccination and surgery, 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. This reduction of mortality was determined primarily by socio-economical and eco-biological factors as medical factors were inadvertent until the 20<sup>th</sup> century by which time the pandemics of infection like syphilis, cholera and diphtheria had already receded. On the contrary, in developing countries the mortality decline was directly determined by medical factors, due to the impact of imported medical technologies (Omran, 1971).

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 (Dutta & Bharucha, 2015). Even though the nation was under the colonial rule for 200 years, a period when the British managed trade and administrative activities, public health interventions were implemented in a half-hearted manner. This is due to the enclavist and mercantilist nature of public health in colonial India i.e. health care were more dedicated toward the military and maintenance of international trade relations respectively (Mushtaq, 2009 & Polu, 2012).

This incomplete elimination of risks of past infectious diseases along with imported medical technologies that can cure the disease has led to an increase in life-expectancy. This has led to a neglect of environmental risks. Health policies in the country have focused largely on medical services such as the provision of curative care and personal prophylactic interventions such as immunization (Gupta, Khaleghian and Sarwal, 2003). The Indian Government uses two strategies for control of infectious diseases i.e. through vertical programmes like National Tuberculosis Control Programs, National Vector Borne Disease Control Program and National Leprosy Eradication Programme. There are provisions for ad-hoc assistance for possible outbreak investigation and control (John, Dandona, Sharma and Kakkar, 2011). Both these strategies are not preventive as the disease gains attention only after its incidence. With increase in life-expectancies chronic lifestyle related diseases started occurring. Risk factor studies of non-communicable diseases now are present in abundance in Indian literature in spite of burden from infectious diseases which are under-represented.

Thus, the main objective of this study is to address this double burden of disease in India i.e. communicable and non-communicable (CD and NCD) with the help of a study that finds out the prevalence of their risk factors (both in the physical and social environments) in two socio-economic groups. This was followed by identification of focal points for their interventions

### **Study Areas**

One lower socio-economic group (LSG) and one higher socio-economic group (HSG) were selected from Pune, a city in western India also known as an emerging mega-city (Butsch, 2008). A megacity is a metropolitan region which has a population of 10 million or more. According to the census of India 2011, Pune metropolitan has a population 4 million. Due to its weather and importance as an information technology hub and education center it attracts students and job seekers from all over the country. Due to urbanization, the city has expanded which has clearly differentiated it into different cityscapes i.e. the oldest part looks different from the newly developed part. To represent these different phases, the study populations were selected from the city-center (highly congested, origin of urbanization, oldest part of the city), neo-urban (newly developing, comparatively less congested, pre-dominantly residential) and

peri-urban part of the city (partly urban and partly rural and 20 km from the main city) representing different phases of urbanization.

### Methodology

A household survey and an observational survey were carried out to find the burden of self-reported morbidity and risk factors of the physical and social environments.

Diseases	Risk Factors
<b>1. Communicable Diseases</b> <ul style="list-style-type: none"> <li>• Water/Food borne diseases (WBD)</li> <li>• Vector/Mosquito Borne Diseases (VBD/MBD)</li> <li>• Acute respiratory diseases (ARD)</li> </ul>	<b>Risks for water borne diseases</b> <ul style="list-style-type: none"> <li>• Drinking water characteristics (water source, timing and treatment)</li> </ul> <b>Risks for Vector Borne Diseases (VBDs)</b> <ul style="list-style-type: none"> <li>• Areas of water pooling (unpaved roads, improper solid waste management and water barrels)</li> </ul> <b>Risk factors for Acute Respiratory Diseases (ARDs)</b> <ul style="list-style-type: none"> <li>• Public transportation</li> </ul>
<b>2. Non Communicable Diseases</b> <ul style="list-style-type: none"> <li>• Hypertension</li> <li>• Diabetes</li> <li>• Cardiovascular Disease (CVD)</li> <li>• Chronic Respiratory Disease (CRD)</li> <li>• Cancer</li> </ul>	<b>Risk factors for NCDs</b> <ul style="list-style-type: none"> <li>• Educational Level</li> <li>• Diet</li> <li>• Risk Habits (smoking, chewing tobacco &amp; drinking alcohol)</li> <li>• Modes of transport</li> <li>• Occupation type</li> </ul>

**Table 1: Information regarding the above diseases and their risk factors were collected**

Household survey was used to collect information about the individual's age, educational level, self-reported morbidity, diet, risk habits, mode of transport and occupation.

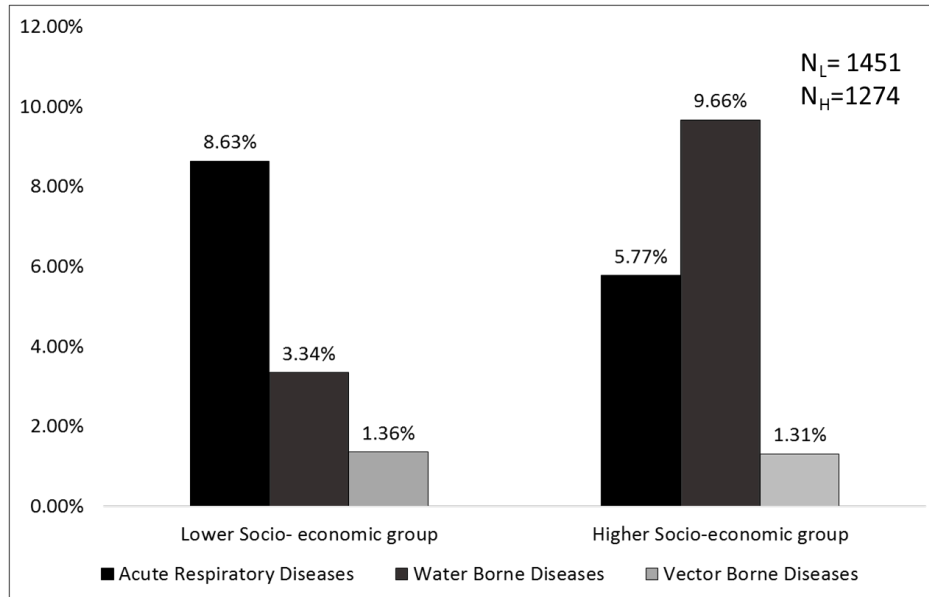
Observational survey was used to collect information on presence or absence of water barrels and presence or absence of communal sanitation.

Relative Risk (RR) was calculated for each risk factor (exposure) and the disease (outcome) that it is responsible for. RR describes the likelihood of developing disease or a negative outcome in a group that is exposed to risk compared to a group that is not exposed to risk. If  $RR > 1$  it implies that the group exposed to risk is more likely to get the disease or is more likely to experience the negative outcome. 95% confidence interval of the RR was calculated.

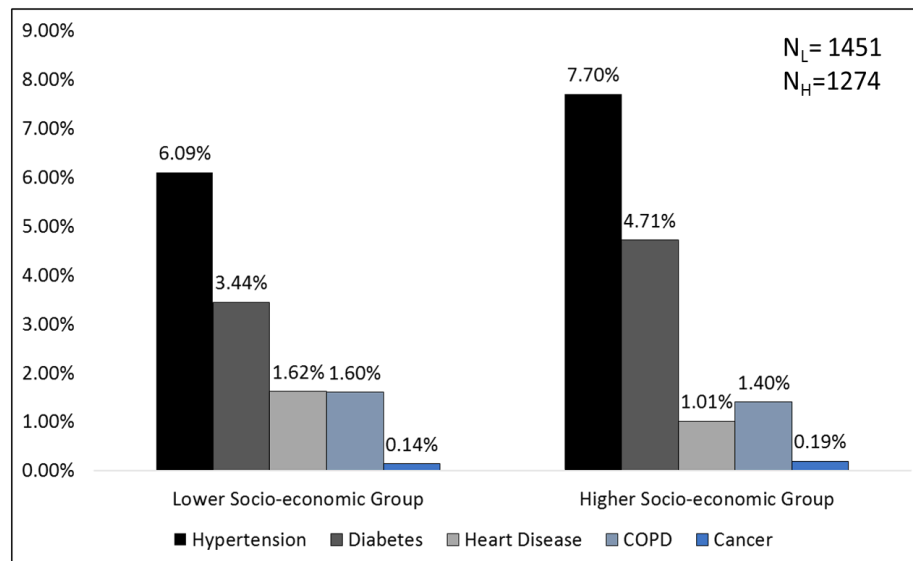
For identification of focal points for intervention, ecological model given by Urie Bronfenbrenner was used for three selected risk factors i.e. drinking water, risk habits and education

### Results

1,451 individuals from lower socio-economic group (LSG) and 1274 from higher socio-economic groups (HSG) were interviewed. The burden of risk prevalent in these two areas will be discussed with respect to the diseases they are responsible for, in the following discourse.



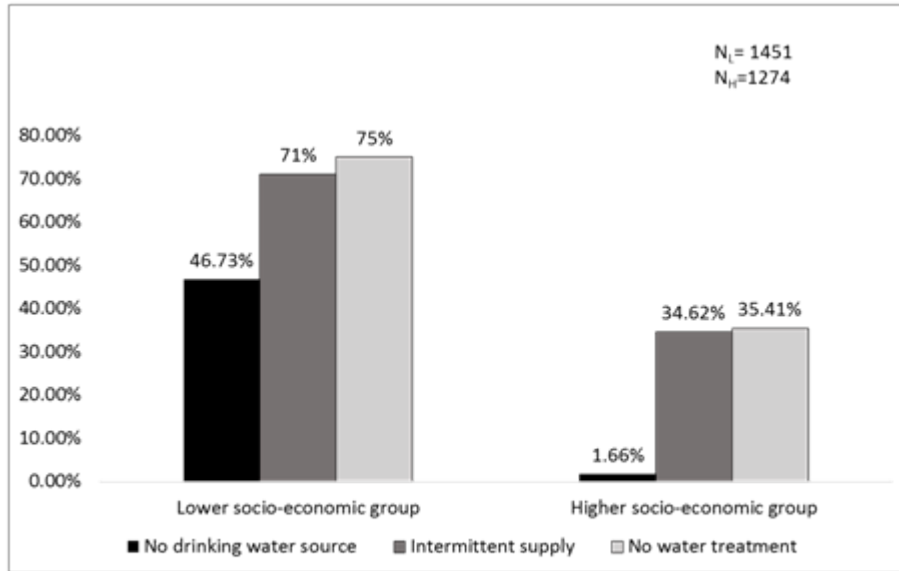
Graph 1a: Self Reported Age adjusted Morbidity from CDs in the 2 socio-economic groups ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)



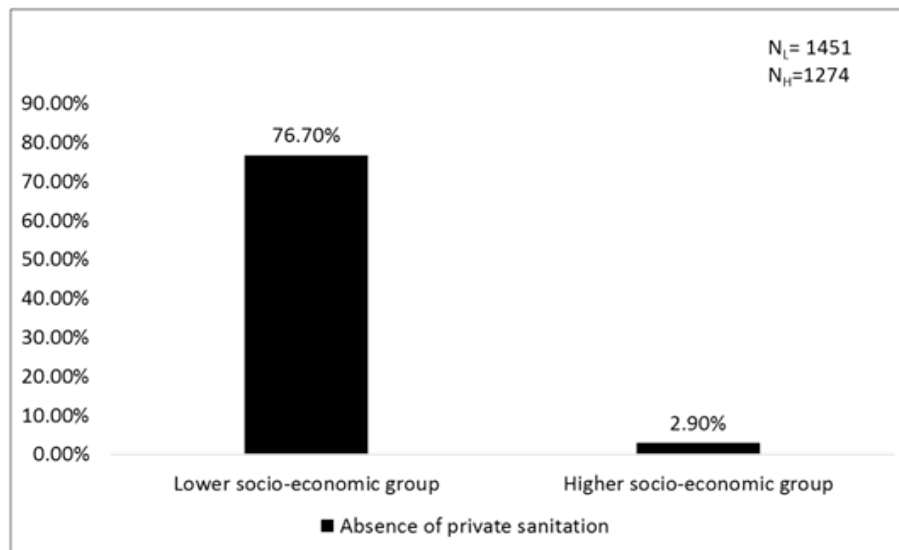
Graph 1b: Self Reported Age Adjusted Morbidity from NCDs in the 2 socio-economic groups ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)

(A) Drinking water & sanitation

Drinking water and sanitation are important determinants of water borne diseases (WBDs). Drinking water characteristics in this study comprise of three components, namely, the source (household tap or public tap), supply timing (continuous or intermittent) and treatment at household level (boil, filter or chemical treatment). Sanitation was divided into private sanitation and communal sanitation.



Graph 2: Proportion of individuals exposed to risks related to drinking water characteristics in the 2 socio-economic groups ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)



Graph 3: Proportion of individuals who lack private sanitation. ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)

Risks from water and sanitation were higher among the lower socio-economic groups (see graph 2 & 3). In the city of Pune, the municipality supplies water for 3-4 hours in the morning to all houses having a piped water supply, which includes even the lower socio-

economic groups. The water then gets stored in a water tank that suffices the needs of the people for the whole day. Thus, the issue of intermittent water supply in the poorer groups is due to the absence of a storage tank in the households, which is not the problem among the affluent individuals. However, Graph 2 also shows that, 34.62% of the population in the affluent group did not receive a continuous water supply which is a considerable proportion. This scenario was particularly seen in the peri-urban part of Pune, where, the main water source is a river and according to the respondents, the water is not treated as efficiently and there is visible sediment from time to time. As a precautionary step the individuals buy bottled water instead. Thus even if they have an access to a continuous water supply, they are not able to use that facility. 35.41% of individuals from HSG also reported that they don't treat the water before drinking, which, even if lower compared to the LSG is still a considerable proportion. Here, it should be kept in mind that the water supplied is treated by the water distribution system, both in the peri-urban and urban households. Thus treating it at home (filtering/boiling/adding chemical) is just a precautionary measure that is taken to avert a disease incident which can occur in case of pipe leakages etc. This is why in spite of a large proportion of the population not treating water the self-reported morbidity remained quite low. This also could be due to under-reporting as gastro-intestinal diseases are frequent, but they recover fast and is not a determinant of mortality. This elicits a casual approach from someone who experienced the symptoms that were not very severe.

Absence of private sanitation showed a drastic disparity with 76.7% of the individuals in the LSG not having a private sanitation compared to 2.9% from the HSG.

<b>RELATIVE RISK BETWEEN WBD &amp; ITS RISKS FACTORS</b>	<b>Lower socio-economic group</b>	<b>Higher socio-economic group</b>
Public tap	RR = 0.57 (CI = 0.31-1.02)ns	RR = 0.19 (CI = 0.04-0.79) s at 0.05
Intermittent water supply	RR = 1.36 (CI = 0.70-2.65)ns	RR = 0.79 (CI = 0.4-1.5)ns
No water treatment	RR = 0.92 (0.49 – 1.72)ns	RR = 1.45 (CI = 0.81-2.60)ns
Sanitation	RR = 0.79 (CI = 0.20-3.12)ns	RR = 0

**Table 2: Relative risk between reporting of water borne diseases and its' risks. ns = not significant**

The RR values (Table 2) indicate that individuals exposed to risks may not get the disease. However,  $RR > 1$ , in case of intermittent water supply and lack of treatment but the values are not significant. The only significant association was in case of public tap in the HSG ( $RR = 0.19$ ,  $P < 0.05$ ), which implies that presence of a public tap (which is considered as a risk,



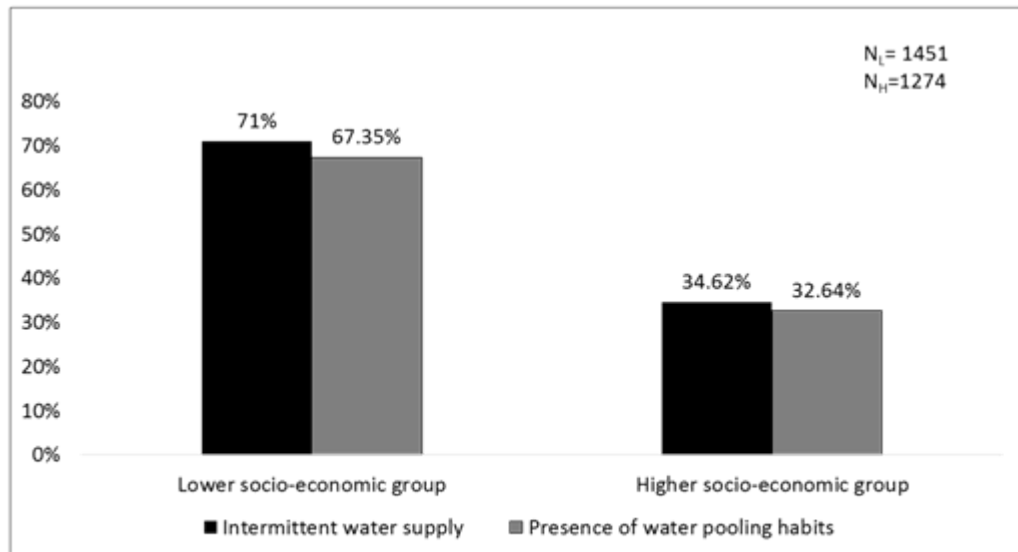
due to its susceptibility to contamination) was not responsible for the disease (as  $RR < 1$ ). This could imply that public tap was not responsible for the disease but the water may have got contaminated during transport or while storage

The RR between sanitation and WBD is 0 in the HSGs as the disease was reported by individuals who had private sanitation thus not having a private sanitation was not responsible for the disease.

This lack of significant expected association could be due to 2 reasons. Either, the water, after its collection from the private tap, was contaminated during storage or the individual was exposed to contaminated food or water elsewhere, information for which is not easy to collect as such events are incidental.

(B) Water pooling habitats (*water barrels, unpaved roads & solid waste management*)

Areas of water pooling are the most important risk factors for spread of mosquito borne/vector borne disease (VBDs). Mosquitoes require standing water bodies to breed and lay eggs thus barrels, unpaved roads and improperly managed solid waste or any other component that allows collection of water are potential sources for mosquito breeding. Intermittent water supply was also considered as a determinant for the disease as it leads to water storage in barrels by the lower socio-economic group outside the house in the absence of a proper storage tank.



Graph 4: Proportion of individuals exposed to risk related to vector borne diseases in the 2 socio-economic groups ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)

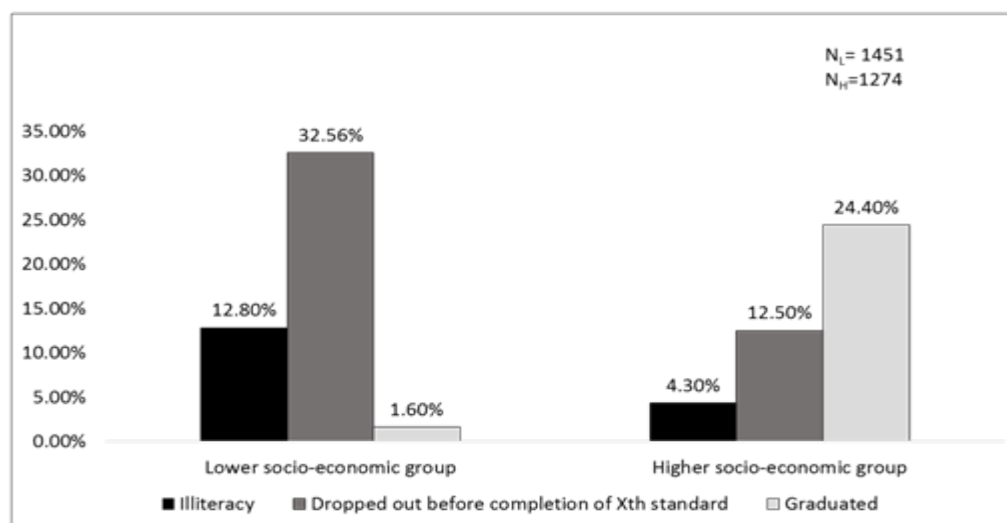
RELATIVE RISK BETWEEN VBD & ITS' RISK FACTORS	Lower socio-economic group	Higher socio-economic group
Intermittent water supply	RR = 0.70 (CI = 0.27-1.77)ns	RR = 0.37 (CI = 0.10-1.29) ns
Presence of water pooling	RR = 0.68 (CI = 0.28-1.71)ns	RR = 1.20 (CI = 0.4-3.6) ns

Table 3: Relative risk between reporting of Vector Borne Diseases and its' risk factors. ns: not significant

There was no significant association between any of the risk factors and reporting of VBDs. There can be 3 main reasons for this. Firstly, the individual may have got bitten elsewhere other than her home environment where water pooling was present. Secondly, presence of water pools don't guarantee the presence of the causative agent in the mosquito. Female mosquitoes need to carry the causative agent (which can either be parasite or virus) in order to be able to spread the disease. Thirdly, mosquitoes breeding on a standing water pool may fly and bite an individual who has not water pooling area in the proximity of her household. Other distal factors like humidity, temperature rainfall may have affected mosquito breeding.

### (C) Educational Levels

Education does not affect an individual's health in a direct way. Rather, it gives rise to other situations. For example, it determines how an individual copes with stress (like resorting to some harmful habit), his/ her level of awareness of diseases and disease preventive strategies or adoption of risk behaviors, which may manifest into a negative health outcome. Thus, it can be said that education is an indirect determinant of health. There was a very clear socio-economic disparity in the number of illiterates, dropouts (before completion of Xth standard) and graduates (see Graph 5).



Graph 5: Attainment of educational levels in the 2 socio-economic groups (only the important stages are mentioned) ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)

An individual was considered to have completed her education after graduation. Since education is not a specific risk factor for any disease its association with reporting of both disease typology was checked i.e. CDs & NCDs

<b>RELATIVE RISK BETWEEN EDUCATION AND THE FOLLOWING DISEASES</b>	<b>Lower socio- economic group</b>	<b>Higher socio- economic group</b>
<b>Communicable Disease</b>	RR = 0.765 (CI = 0.57- 1.03)ns	RR = 0.76 (CI = 0.46-1.26)ns
<b>Non-communicable Disease</b>	RR = 4.522 (CI = 2.99-6.82) p<0.0001	RR = 2.334 (CI = 1.74-3.12) p<0.0001

**Table 4: Relative Risk between education and disease outcome ns: not significant**

It is very clear from Table 4, that lack of basic education does not increase the likelihood for an individual to get infected by a CD which it does for an NCD.

In both groups individuals lacking basic education are more prone to suffer from an NCD and this association is stronger in the LSG. Lack of basic education leads one to adopt risky habits like tobacco, smoking and drinking either due to peer pressure or as mechanisms cope with stress. This is due to lack of awareness of the consequences as well as unawareness of constructive ways to manage stress. This gets translated into a chronic disease like chronic respiratory disease (CRD), cardiovascular disease (CVD) and cancer (oral cancer, lung cancer). Cancer reporting was very low (see Graph 1b). The comparatively lower relative risk in the higher socio-economic group is due to presence of a very low proportion of individuals lacking basic education (most are graduates).

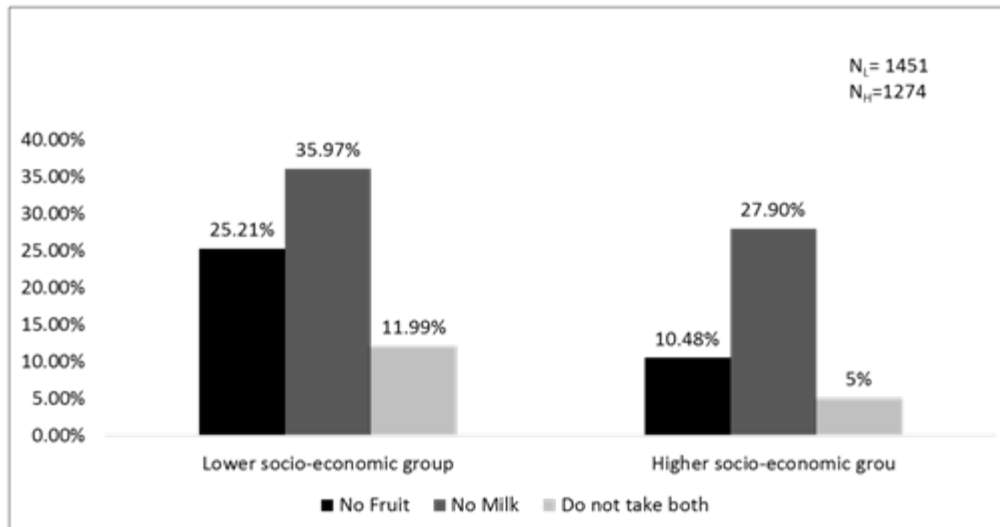
Lack of basic education did not show any significant association with self-reported morbidity of CDs. Most risk factors of CDs lie in the public domain. Public domains are public places of work, education, commerce and recreation as well as the streets and fields not under the control of a household whereas domestic domains are occupied by and are under control of a household (Cairncross, Blumenthal, Kolksy Moraes and Tayeh, 1996). For e.g. in case of water borne diseases risk factor of the public domain is the water distribution system. If the water in the distribution system gets contaminated then it can cause an outbreak indiscriminately irrespective of whether an individual is educated or not whereas risk factors of domestic domains are treatment of water at household level i.e. (boiling or filtering) and maintenance of public water taps which are dependent on hygienic behavior of the individual or the family. Similarly, for vector borne disease the water pooling habitats like unpaved roads (that can collect water post monsoon) is beyond the control of a household and under the control of the city administration. Thus, presence of unpaved roads is not associated to one's educational background. The risks of the domestic domain are presence of water barrels that the household use to store water and solid waste management that depends on both individual and community

behaviors. Also other instances like, the causative agent (parasite in case of malaria) needs to be carried by the mosquito. Number of water pools may determine number of mosquitoes but it does not guarantee the fact that each of the mosquitoes will carry the causative agent. Secondly, mosquitoes breeding in one area can fly and bite an individual who has no water pools in her vicinity. These factors explain why there was no association between education and reporting of CD.

On the other hand, risk factors of NCDs are linked to an individual's lifestyle which one adopts and modifies also depends on his level of awareness about diseases associated with a poor diet and other lifestyle attributes. This could have led to the association between the disease and its risk.

#### (D) Diet

An improper or unhealthy diet can lead to NCDs like diabetes and hypertension which are secondary risks for cardiovascular disease (Ellingsen, Hjerkin, Arnesen, Seljeftot, Hjermann and Tonstad, 2006). Individuals were asked if they consume milk and fruit products on a daily basis.



Graph 6: Proportion of individuals not consuming fruits and milk in the 2 socio-economic groups ( $N_L$  = Sample size in LSG  $N_H$  = Sample size in HSG)

There was significant difference in the responses ( $p < 0.001$ ). More number of individuals reported that they do not consume milk and fruits on a daily basis. Relative risk was calculated and it was found that in the higher socio-economic group not consuming fruits and milk is associated with NCD reporting.

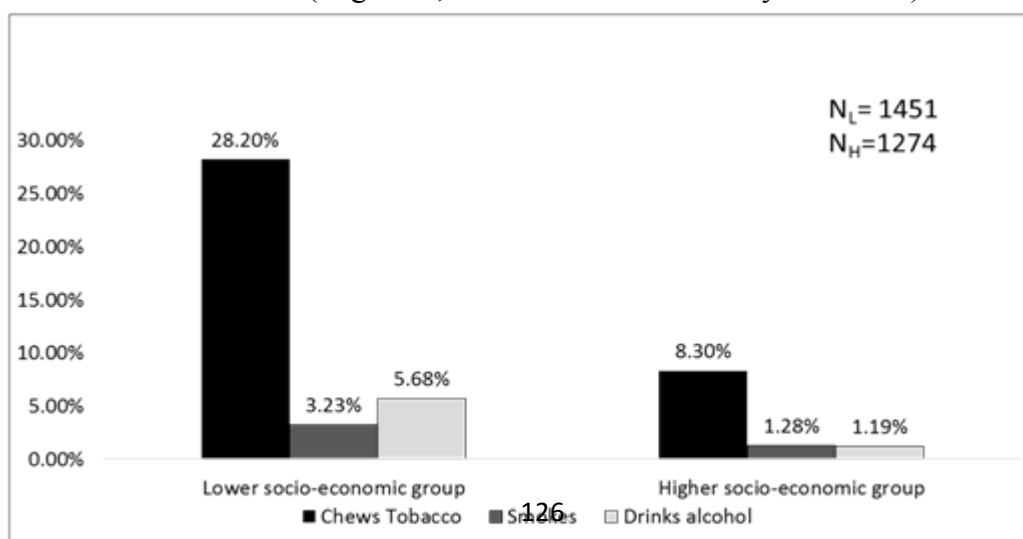
RELATIVE RISK BETWEEN NCD & INTAKE OF FRUITS & MILK	Lower socio-economic group	Higher socio-economic group
No fruit	RR = 0.81 (CI= 0.52-1.26)ns	RR = 1.61 (CI = 1.09-2.38)p<0.05
No milk	RR = 0.91 (CI = 0.63-1.34)ns	RR = 1.28 (CI= 0.93-1.74) ns
Don't have any	RR = 1.11 (p<0.66-1.87)ns	RR = 2.06 (CI = 1.31-3.25) p<0.05

**Table 5: Relative Risk between Diet & NCD reporting (NCDs are hypertension, diabetes and cardiovascular disease) ns: not significant**

Not consuming fruits and both milk and fruits showed a strong significant association with reporting of either of the NCDs, which in this case included hypertension, diabetes and cardiovascular diseases. Diet was not a significant determinant in the LSG. The strong association in the HSG may also be a reflection of poor dietary habits like fast food and food containing high fat that could be afforded by them. On the other hand, in spite of a higher number of individuals in the poorer group reporting that they do not consume fruits and milk on a daily basis, their routine diet is simple containing staple food like rice, cereals and vegetables. Also, due to unaffordability they are not exposed to rich and high fat foods.

#### (E) Risk habits

Risk habits comprised of smoking, drinking alcohol and chewing of tobacco. Smoking is a risk factor for lung cancer, chronic respiratory diseases as well as cardiovascular diseases, chewing of tobacco is exclusively related to oral cancer and alcohol to cardiovascular diseases (Sugathan, Soman and Sankaranarayanan 2008)



**Graph 7: Proportion of individuals (age adjusted) with risk habits in the 2 socio-economic groups ( $N_L$  = Sample size in LSG,  $N_H$  = Sample size in HSG)**

Chewing of tobacco was the most common risk habit followed by alcohol and smoking in the LSG. In both the groups risk habits commenced at 11-20 years. Age specific risk habit was highest in the age group 61-70 years with 83.63% in the LSG and 35.04% in the age group 51-60 years in the HSG. Since number of cancer cases was very low and was not of oral or lung type they were ignored from the analysis of association.

<b>RISK HABIT &amp; EDUCATION</b>	<b>Lower Socio-economic Group</b>	<b>Higher Socio-economic group</b>
<b>To what extent education influences risk habit of an individual?</b>	RR = 5.84 (CI = 4.61-7.41) p<0.0001	RR = 4.28 (CI = 3.10-5.90) P<0.0001

**Table 6: Relative risk between education and risk habit**

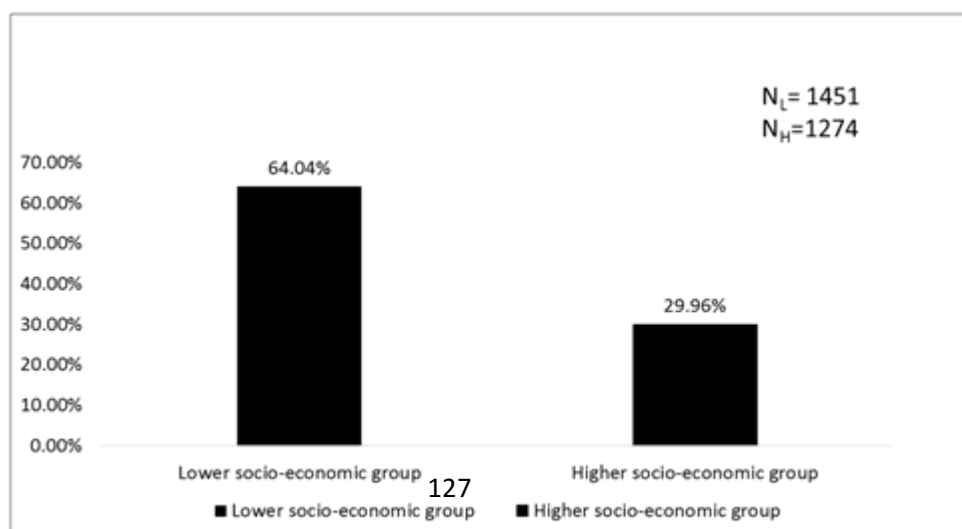
Table 6 shows that individuals lacking basic education are 5.84 times and 4.28 times more likely to report a risk habit in the LSG and in the HSG respectively. Individuals not having basic education was considered the exposed group in the analysis

<b>RELATIVE RISK BETWEEN RISK HABIT AND NCD</b>	<b>Lower socio-economic group</b>	<b>Higher socio-economic group</b>
<b>To what extent does risk habit give rise to an NCD (CVD, Diabetes, hypertension and COPD)</b>	RR = 3.88 (CI = 2.68-5.63) p<0.0001	RR = 2.79 (CI = 1.96-3.97) p<0.0001

**Table 7: Relative risk between risk factors and NCDs (CVD, Hypertension, COPD)**

Table 7 shows that an individual having any one of the risks is 3.88 times and 2.79 times more prone report an NCD in the LSG and HSG respectively.

#### (F) Transportation



**Graph 8: Proportion of individuals who take public means of transport in the 2 socio-economic groups (N<sub>L</sub> = Sample size in LSG N<sub>H</sub> = Sample size in HSG)**

In this study, mode of transportation was divided into 2 categories i.e. public and private. Public modes included bus, auto, travelling on foot and train whereas private modes included two wheelers and private cars. Using public mode of transport on a daily basis can be a risk for respiratory infections both acute and chronic (Dora, 1999) in a country like India due to high congestion and air pollution.

<b>RELATIVE RISK BETWEEN PUBLIC MODE OF TRANSPORTATION AND RESPIRATORY DISEASE</b>	<b>Lower socio- economic group</b>	<b>Higher socio- economic group</b>
<b>Public Mode of Transport &amp; Acute Respiratory Disease</b>	RR = 1.44 (CI = 0.99- 2.08)p=0.05	RR = 1.04 (CI = 1- 1.05)p<0.05
<b>Public Mode of Transport &amp; Chronic Respiratory Disease</b>	RR = 0.79 (CI = 0.52-3) ns	RR = 2.35 (CI = 0.81 – 6.84)ns

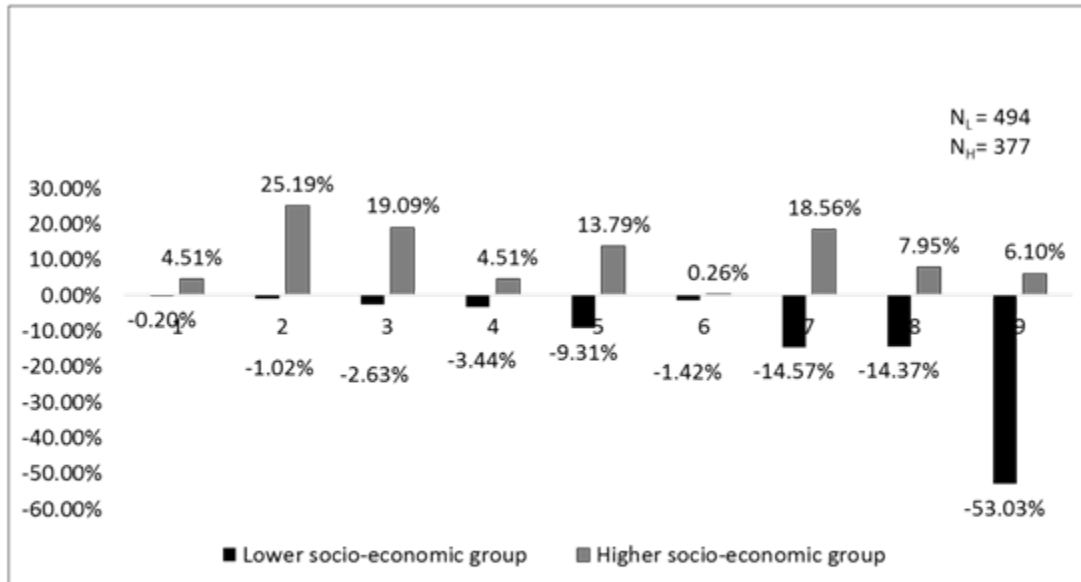
**Table 8: Relative risk between public modes of transport and respiratory diseases in the 2 socio-economic groups. ns: not significant**

Public modes of transport showed significant association with acute respiratory diseases (cold and cough) in both the socio-economic groups. Acute respiratory diseases (ARD) are also the number one cause of morbidity in India (WHO, 2008).

Even though, in the higher socio-economic group individuals who take the public transport are 2.35 times to get a chronic respiratory disease (CRD), the value is not significant. This may be due to very low proportion of individuals reporting CRD.

#### (G) Occupation

Besides education, occupation is another indicator of one's socio-economic status as it determines the income level of the individual and her expending abilities which also includes affordability of healthcare. Occupation of the employed individuals were categorized into 9 categories (as provided by the National Classification of Occupation of India) which has classified occupations from high end jobs to low end jobs ( e.g. from professionals, legislators and associates to elementary occupations like owning of food stalls, waste pickers and other jobs that don't require any definite skill or educational qualification).



Graph 9: Proportion of individuals belonging to different occupational categories ( $N_L$ =No. of employed individuals in a classifiable occupational category in the LSG  $N_H$ = No. of employed individuals in a classifiable occupational category in the HSG)

The proportion of individuals who are unemployed were significantly lower in the lower socio-economic group (23.15%) compared to the higher socio-economic group (26.67%) ( $p < 0.001$ ). Number of employed individuals were also higher in the LSG (38.12%) compared to HSG (34.60%). The rest are either retired, studying or small children. The above graph shows occupational classification of the employed respondents.

Occupation has been associated with hypertension and cardiovascular diseases (Saha, Dey, Samanta and Biswas, 2008; Abt and Tranter, 1999) depending on the level of stress and strain (both mental and physical) of the job. After classifying the individuals according to the occupations they belonged to, they were further divided into 2 categories. Classification ranging from 1-6 were considered to be high-end jobs and 7-9 were considered as low end jobs. Relative risk between a low-end job and reporting of NCD was then calculated.

RELATIVE RISK BETWEEN OCCUPATION AND NCD	Lower socio-economic group	Higher socio-economic group
Occupation & Hypertension	RR = 3.76 (CI = 0.91-15.60)ns	RR = 0.38 (CI = 0.13-1.09) ns
Occupation & Cardiovascular Disease	RR = 0.69 (CI = 0.18-2.58)ns	RR = 0.67 (CI = 0.07-6.39) ns

Table 9: Relative risk between occupational type and NCD (cardiovascular, hypertension). ns: not significant



There was no significant association between occupation type and NCD i.e. CVD and hypertension. Here it is important to note that being exposed to health risks in the workplace also depends on the awareness of the employee and precautionary measures provided by the employers. Different occupation type has different health hazards thus in order to learn about occupational health hazards, occupation specific risks need to be studied

#### Focal points for intervention

Diseases depend on risk factors. Risk factors further, have under-lying causes for their introduction, either into the physical environment or in humans. These underlying factors can be present at the micro (lowest) level e.g. one's local environment or at the macro (highest) level e.g. laws and policies implemented to govern a region. In 1979, Urie Bronfenbrenner gave the Ecological Model of Health Behavior. The model states that there are multiple influences on specific health behaviors that include factors at, intrapersonal, interpersonal, organizational, community and public policy levels (Sallis, Owen and Fisher, 2008). They are commonly called as micro meso and exo-systems. A micro-system is the immediate setting of an individual which includes the home environment, school environment, work environment, leisure environment etc., the meso-system contains the interrelations among the major settings containing the individual at a particular point in his or her life e.g. stress at work place and support system at home can increase or decrease the level of stress. Finally the exo-system is an extension of the meso-system embracing the concrete social structure both formal and informal that encompasses, the political and cultural environments, decision making at policy levels (Bronfenbrenner, 1976). Influences on behaviors interact across these different levels. Thus, multi-level interventions should be most effective in changing behavior. Unless one addresses these underlying factors these risks cannot be eliminated.

## Environmental Health Monitoring for India: An Emerging Nation

<b>RISK FACTORS</b>	<b>MICROSYSTEM</b>	<b>MESOSYSTEM</b>	<b>EXOSYSTEM</b>
Drinking water (with respect to source, treatment and timing)	<ol style="list-style-type: none"> <li>1. Socio-economic status of the individual (determines whether he/she has a piped water, continuous water supply)</li> <li>2. Behavioral attributes determining treatment at household level, water storage</li> <li>3. Hygienic practices</li> </ol>	<ol style="list-style-type: none"> <li>1. Treatment of water by the public distribution system</li> <li>2. Maintenance of distribution pipes</li> <li>3. Quality of quality provided in public places where the individual spends sufficient amount of time</li> </ol>	<ol style="list-style-type: none"> <li>1. Public distribution system</li> </ol>
Education	<ol style="list-style-type: none"> <li>1. Socio-economic characteristics of the individual</li> <li>2. Perceived benefits of education by the individual and his/her family members</li> <li>3. Educational attainment of family members</li> <li>4. Social group the individual belongs to</li> </ol>	<ol style="list-style-type: none"> <li>1. Perceived benefits of the society (peers and relatives) the individual belongs to</li> <li>2. Infrastructure of school and distance from home</li> <li>3. Attitude and dedication of the teacher</li> <li>4. Incentives like free lunch and fee waiver</li> <li>5. Child Labor (as it does not allow a child to go to school)</li> </ol>	<ol style="list-style-type: none"> <li>1. Educational policies</li> <li>2. Investment in education</li> <li>3. Policies on child labour</li> </ol>
Risk habits	<ol style="list-style-type: none"> <li>1. Risk habits present/absent among family members</li> <li>2. Level of addiction</li> <li>3. Family support or attitude of the family members towards that risk habit</li> <li>4. Peer group</li> <li>5. Stress level</li> </ol>	<ol style="list-style-type: none"> <li>1. Advertisements endorsing use or</li> <li>2. Physician counselling</li> <li>3. Availability of shops in the vicinity of house or work-place</li> <li>4. Easy availability due to cheap price</li> </ol>	<ol style="list-style-type: none"> <li>1. Imposing of taxes e.g. tobacco taxation</li> </ol>

**Table 10: Microsystem, meso-system and exo-system of the risk factors that were identified**

## Conclusion

To address the issue of disease burden from both communicable & non-communicable diseases in India the study emphasizes the need for an environmental health monitoring system that would monitor risk factors of the physical (non-living) as well as the social environment taking into consideration the stark socio-environmental heterogeneity of Indian scenario.

From the household survey we see that certain risk factors like education and risk habits have a strong association with the disease but in other cases the association is weak and not significant i.e. drinking water, areas of water pooling, diet, occupation etc. One should not conclude from here that since statistical association is missing the risks can be allowed to linger on in the environment. Risks are not causative agents (Last, 2001) rather, they are attributes that increases the susceptibility of one to a disease, according to World Health Organization as of April 2016. Presence of risk factors in the environment are warnings of possible untimely negative outcomes in future.

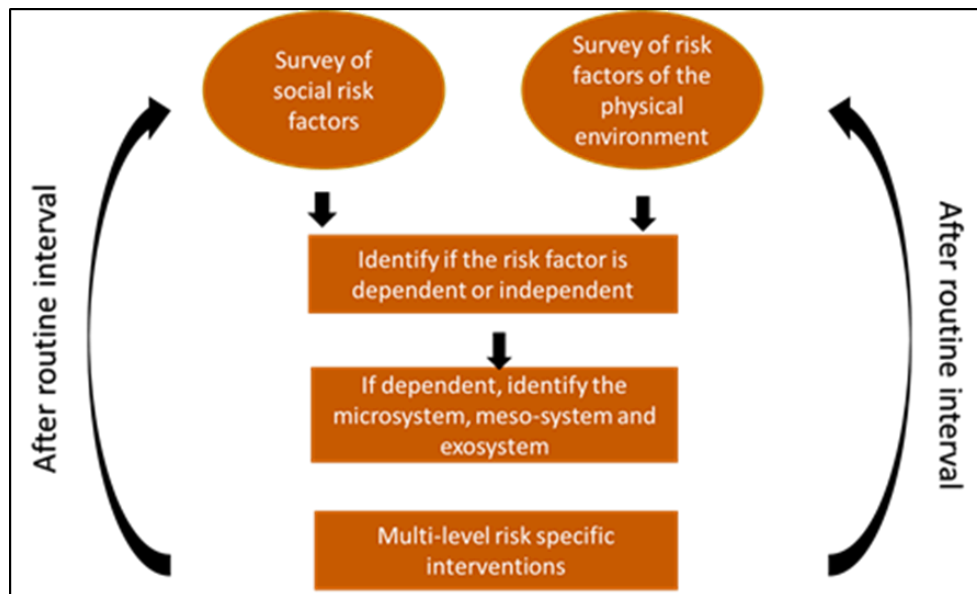


Fig1: Framework for an environmental health monitoring system

Thus, an environmental health monitoring system will monitor the prevalence of all known risks, followed by interventions that will identify stakeholders at multi-levels who will help in working towards eliminating the risk. An ecological approach towards monitoring of these both kinds of risk factors need to be adapted, as elimination of these from the individual as well as from the environment is complex. Acknowledgement of not only the dynamic relationship between humans and their environments but also differentiation of this relationship into different levels are pre-conditions to focused and effective interventions.

## References

- Adams, F., & others. (1929). *The Genuine Works of Hippocrates: Translated from the Greek, with a Preliminary Discourse and Annotations* (Vol. 1). William Wood.
- Bahonar, A., Sarrafzadegan, N., Kelishadi, R., Shirani, S., Ramezani, M. A., Taghdisi, M. H., & Gharipour, M. (2011). Association of socioeconomic profiles with cardiovascular risk factors in Iran: the Isfahan Healthy Heart Program. *International Journal of Public Health*, 56(1), 37–44.
- Barker, R. G. (1968). *Ecological psychology: Concepts and methods for studying the environment of human behavior*. Stanford University Press. Retrieved from <https://books.google.co.in/books?hl=en&lr=&id=p1arAAAAIAAJ&oi=fnd&pg=PA1&dq=Roger+Barker+1968&ots=heWzBSDST7&sig=x9GhZ1EuUHbafVc0mzxTaFamO5o>
- Bronfenbrenner, U. (1976). The experimental ecology of education. *Educational Researcher*, 5(9), 5–15.
- Butsch, C. (2008). 2.1 Access to Healthcare in the Fragmented Setting of India's Fast Growing Agglomerations—a Case Study of Pune. *Resilience and Social Vulnerability*
- Cairncross, S., Blumenthal, U., Kolsky, P., Moraes, L., & Tayeh, A. (1996). The public and domestic domains in the transmission of disease. *Tropical Medicine & International Health*, 1(1), 27–34.
- Chaix, B., Kestens, Y., Bean, K., Leal, C., Karusisi, N., Meghiref, K., others. (2011). Cohort Profile: Residential and non-residential environments, individual activity spaces and cardiovascular risk factors and diseases—The RECORD Cohort Study. *International Journal of Epidemiology*, 40(1), 107.
- Cohen, D., Spear, S., Scribner, R., Kissinger, P., Mason, K., & Wildgen, J. (2000). “Broken windows” and the risk of gonorrhea. *American Journal of Public Health*, 90(2), 230.
- Diez-Roux, A. V., Nieto, F. J., Caulfield, L., Tyroler, H. A., Watson, R. L., & Szklo, M. (1999). Neighbourhood differences in diet: the Atherosclerosis Risk in Communities (ARIC) Study. *Journal of Epidemiology and Community Health*, 53(1), 55–63.
- Drèze, J., & Sen, A. (2013). *An uncertain glory: India and its contradictions*. Princeton University Press.
- Dutta, S., & Bharucha, E. (2015). Environmental Health Monitoring: A Risk Factor Approach Towards Health. *The International Journal of Humanities & Social Studies*, 3(8), 178–185.
- Dutta, S., & Bharucha, E. (2016). Conceptualizing “Environmental Health” with Respect to the Socio-Environmental Disparity and Communicable Disease Burden in India. *Available at SSRN 2781596*. Retrieved from [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=2781596](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2781596)
- Ebrahim, S., Montaner, D., & Lawlor, D. A. (2004). Clustering of risk factors and social class in childhood and adulthood in British women's heart and health study: cross sectional analysis. *Bmj*, 328(7444), 861.
- Government of India. (2011). *Slums in India: A Statistical Compendium*. Ministry of Housing and Urban Poverty Alleviation.
- Gupta, M. D., Khaleghian, P., & Sarwal, R. (2003). *Governance of Communicable Disease Control Services*. Washington: Development Research Group, the World Bank. Retrieved from [https://www.researchgate.net/profile/Monica\\_Das\\_Gupta/publication/23549578\\_Governance\\_of\\_Communicable\\_Disease\\_Control\\_Services\\_A\\_Case\\_Study\\_and\\_Lessons\\_from\\_India/links/02e7e518aa67e0b713000000.pdf](https://www.researchgate.net/profile/Monica_Das_Gupta/publication/23549578_Governance_of_Communicable_Disease_Control_Services_A_Case_Study_and_Lessons_from_India/links/02e7e518aa67e0b713000000.pdf)
- John, T. J., Dandona, L., Sharma, V. P., & Kakkar, M. (2011). Continuing challenge of infectious diseases in India. *The Lancet*, 377(9761), 252–269.
- Kaplan, S. (1983). A model of person-environment compatibility. *Environment and Behavior*, 15(3), 311–332.
- Khan, M. (2016, February 8). Growth Star India Overtakes China. *The Telegraph*.
- Krieger, N., Chen, J. T., Waterman, P. D., Rehkopf, D. H., & Subramanian, S. V. (2005). Painting a truer picture of US socioeconomic and racial/ethnic health inequalities: the Public Health Disparities Geocoding Project. *American Journal of Public Health*, 95(2), 312–323.
- Last, J. M., Association, I. E., & others. (2001). *A dictionary of epidemiology* (Vol. 4). Oxford Univ Press. Retrieved from <http://aje.oxfordjournals.org/content/137/10/local/back-matter.pdf>

- Ministry of Health & Family Welfare. (2015). *Draft National Health Policy 2015*.
- Mushtaq, M. U., & others. (2009). Public health in British India: A brief account of the history of medical services and disease prevention in colonial India. *Indian Journal of Community Medicine*, 34(1), 6.
- Omran, A. R. (1971). The epidemiologic transition: a theory of the epidemiology of population change. *The Milbank Memorial Fund Quarterly*, 509–538.
- Pickett, K. E., & Pearl, M. (2001). Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *Journal of Epidemiology and Community Health*, 55(2), 111–122.
- Polu, S. L. (2012). *Infectious Disease in India, 1892-1940: Policy-making and the Perception of Risk*. Palgrave Macmillan. Retrieved from <http://books.google.co.in/books?hl=en&lr=&id=BLGPwzRQWgYC&oi=fnd&pg=PP2&dq=infectious+diseases+in+india+1892-1940&ots=kYTYrZMoPy&sig=zcsFScxRGXIruXcGPsbZ-Ap9BEQ>
- Razzaque, A., Nahar, L., Mustafa, A. H. M. G., Ahsan, K. Z., Islam, M. S., & Yunus, M. (2011). Sociodemographic differentials of selected noncommunicable diseases risk factors among adults in Matlab, Bangladesh: findings from a WHO STEPS survey. *Asia-Pacific Journal of Public Health*, 23(2), 183–191.
- Rosen, G. (1993). *A history of public health*. JHU Press.
- Rosen, G. (1958). *A history of public health*. New York: MD Publication INC.
- Saha, R., Dey, N. C., Samanta, A., & Biswas, R. (2008). A comparison of cardiac strain among drillers of two different age groups in underground manual coal mines in India. *Journal of Occupational Health*, 50(6), 512–520.
- Sallis, J. F., Owen, N., & Fisher, E. B. (2008). Ecological models of health behavior. *Health Behavior and Health Education: Theory, Research, and Practice*, 4, 465–486.
- Sugathan, T. N., Soman, C. R., & Sankaranarayanan, K. (2008). Behavioural risk factors for non-communicable diseases among adults in Kerala, India. *The Indian Journal of Medical Research*, 127(6), 555–563.
- Winkleby, M. A., Jatulis, D. E., Frank, E., & Fortmann, S. P. (1992). Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health*, 82(6), 816–820.
- World Health Organization (2008). *The Global Burden of Disease: 2004 Update*.
- World Health Organization Retrieved from: [http://www.who.int/topics/environmental\\_health/en/](http://www.who.int/topics/environmental_health/en/) Accessed on April 11, 2016
- World Health Organization Retrieved from: [http://www.who.int/topics/risk\\_factors/en/](http://www.who.int/topics/risk_factors/en/) Accessed on April 11, 2016
- Yusuf, S., Hawken, S., Ôunpuu, S., Dans, T., Avezum, A., Lanas, F., others. (2004). Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *The Lancet*, 364(9438), 937–952.