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Indoor Air Quality in Asia

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INDOOR ENVIRONMENTAL FACTORS AND HEALTH: THE NEED FOR COMMON SENSE

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ABSTRACT

Several factors contribute to making the indoor environment different from the outdoor environment: the list includes the sheltering effect of roofing and walls, indoor sources of cooking and heating fumes, chemicals and particles including fibres emitted by building materials and fabrics, domestic chemicals including insecticides, the occupying people and their hobbies, animal pets, and mechanical systems for raising or lowering temperature and humidity. Where there are no effective barriers between the indoor and outdoor environments then the quality of the outdoor air is likely to be the most important determinant of the quality of the indoor air. In certain circumstances radon daughters and possibly asbestos fibres may contribute to lung cancer risk. However, in most countries cooking and heating fumes - especially the carbon monoxide, oxides of nitrogen and particulate content of such fumes - are by far the most important contributors to the risk of chronic lung disease, including lung cancer, from indoor air pollution. On the other hand, the spread of infections, particularly organisms that cause upper respiratory disease, and allergies, particularly from house dust mites and fungal spores, are responsible for most of the short term illnesses due to poor indoor air quality. The need to pay more attention to the importance of the spread of infectious diseases in indoor environments is emphasised.

INTRODUCTION

The aim of this brief survey is to put the relationship between the indoor environment and health into perspective, while leaving it to others to discuss particular problems in detail.

Factors Which Determine the Quality of the Indoor Environment

The quality of the indoor environment has many determinants. Apart from the purity, temperature and humidity of the ambient air, there is the level and kind of noise, the level and kind of lighting, and the presence or absence of inapparent hazards such as radon and its radioactive daughters to be considered.

The quality of the indoor environment is definable at two different levels: (1) comfort and well-being, and (2) risks to health: immediate or long-term.

In any community, however, it is not so much the actualities of conditions as the expectations and perceptions which determine whether there is any concern and, if so, the level of that concern, about the quality of the indoor environment.

Expectations, Perceptions and Adaptability

Expectations and perceptions are especially important in relation to a sense of well-being and comfort. Given time, people can and do get used to, and adjust to, low or high ambient temperatures, and low or high ambient humidities. They adjust, partly by wearing clothes that are appropriate to the circumstances, and partly by adjusting their intakes of calories and fluids. Physiologically, they adjust by increasing or decreasing the blood supply to the skin, and by increasing or decreasing heat loss through sweating. It is only when the reality of situations differs markedly from expectations, and/or circumstances change faster than adjustment or adaptation can occur, that people are discomfited and complain.

In temperate and cold climates - particularly in richer countries - ambient temperatures and humidity within workplaces and homes have increasingly been maintained at a constant level, despite the weather, by means of central heating and air-conditioning systems. As a consequence, people living in such countries have, over the years, got used to higher ambient temperatures during cold seasons, and to wearing less clothing in the winter. In turn, this has meant that they are apt to feel uncomfortably cold in circumstances which would have been quite acceptable to their forebears.

Does Central Heating Increase the Incidence of Atopic Symptoms?

Has this process of getting people used to higher ambient temperatures during the cold months of the year had any beneficial or adverse effects on health? This is a difficult question to answer, because so many other things have changed. In Britain, for instance, the increasing availability of central heating during the last 50 years has coincided with a dramatic reduction in the level of outdoor air pollution from industrial sources, as well as from domestic, chimneys. In parallel with these changes, there has been a steep fall in the incidence of chronic bronchitis and phlegm production. Forty years ago, coughing and spitting in the street were rife, and notices requesting people not to spit in public vehicles under threat of fine were common. Nowadays, spitting in public is rare, and notices about the habit are nowhere to be seen.

On the other hand, symptoms of atopic diseases, such as vasomotor rhinitis, hay fever, and asthma seem to be on the increase - perhaps more so in the centres of large cities than in rural areas, where one would expect levels of allergic pollens, etc. to be higher. Could it be that the hotter, less humid air of centrally-heated houses and offices predisposes people to these symptoms? Alternatively,

as has been suggested (R. Davies - unpublished data), is it a change in the predominant kind of pollution of the outdoor air - from heavy particulate pollution (from coal-burning fires) to higher irritant gaseous pollution (e.g. oxides of nitrogen from vehicular exhaust fumes) - that has brought about the changes?

Climate and Wealth as Determinants of Indoor Air Quality

In countries where the ambient temperature remains warm or hot throughout the 24 hours of each day, and throughout the whole year, and where people are generally not wealthy enough to afford air-conditioning systems, the quality of the indoor air is largely determined by that of the outdoor air, while the quality of the outdoor air is dependent on the proximity of industrial sources of air pollution, the prevailing winds, the frequency of temperature inversion, and location in relation to main roads with traffic-generating vehicular exhaust fumes. In such situations, there is little scope for improving the quality of the indoor air, except through measures to improve the quality of the outdoor air. Probably the most important consideration in this regard is the building of better road systems that can cope with the flow of traffic that exists now, or that is expected in the future. The next measure required is the progressive introduction of regulations to restrict and control the level of vehicular exhaust emissions. Thirdly, legislation needs to be introduced effectively to control the pollution of the outdoor atmosphere by the noxious gases and particles which are emitted by factory and domestic chimneys. Until, and unless, such measures are taken, there is likely to be little that can be done to improve the quality of indoor air.

However, the situation is different in countries where, during parts of the day or year, temperatures fall below levels which are reasonably tolerable. In such circumstances, it is common for heating systems which emit health-damaging fumes to be in use, and for women to spend long periods exposed to cooking fumes in inadequately ventilated, or wholly unventilated, kitchens. This combination of circumstances is associated with very serious risks to health in dwellings in rural, as well as urban, regions in many undeveloped and developing countries.

Both chronic respiratory disease, in the form of emphysema which leads to death from cor pulmonale, and lung cancer are commonly seen, particularly among women, because of the heavy exposure to heating and cooking fumes. Obviously, given the level of general poverty, there is no quick or practical way of solving these problems. Educating people with a regard to the importance of ventilation could help a little, and so could research on how to ventilate simple dwellings without incurring major heat loss. However, at the end of the day people give a higher priority to their needs to eat and keep warm, than they do to the quality of the air they breath, or even to their long-term health prospects.

The Priorities in Human Needs

Temperature, humidity, noise, shelter from the wind and rain, air quality, and cleanliness are different aspects of the indoor environment which have different priorities. In Table 1, there is a list of a range of human needs, and it can be seen that, whereas warmth and shelter merit high priority, general cleanliness and absence of obnoxious fumes come lower on the list, whilst the purity and quality of the indoor air come lower still. One may deduce from this table, that good indoor air quality is only a topic for consideration among richer people, in times of peace and plenty. It is not a topic that commands interest, or even debate, in times of war or famine, when there are many more pressing things to think about. Similarly, air purity does not merit a high priority among very poor people living in slums.

Table 1. Priorities in human needs

1.	Food, water, warmth, shelter from wind and rain.
2.	Medicines, freedom from pain, freedom from tyranny and fear.
3.	Affection, companionship, sex, entertainment, work satisfaction, religious practice.
4.	General cleanliness, absence of obnoxious fumes.
5.	Comfort, relaxation, luxuries, good air quality.Table 2.Most serious risks to health associated with the indoor environment

Notwithstanding the unpalatable truth of this listing of priorities, it behooves humans always to be striving to improve their own environment, and that of others. In this regard, it is essential, first, to identify those aspects of the indoor environment which can, and do, seriously impinge on health as distinct from well-being. Only if this is done, will one be in a position to see that such resources as are available are focussed to the best advantage of the people.

Priorities in Research on the Indoor Environment

In England, there is an old joke which, no doubt, has its counterparts in other countries. A policeman, on finding a drunken man crawling around and round a lamp post, asks him what he is doing. The drunken man says he is looking for a shilling which he has dropped on the ground. The kind policeman also crawls around the lamp post, looking for the shilling. After a while, however, when neither of them have found it, the policeman asks the drunken man, "Are you sure you dropped the shilling here?" The drunken man replies, "Oh no, I didn't drop it here, but further along the road." "Then why are you looking for it here?," asks the, now angry, policeman. "Because the light is better here!," says the drunk.

I cannot help feeling that the recent history of research on indoor air quality

has much in common with this story. Clearly, what needs most urgently to be done, is to find ways of preventing deaths from exposure to carbon monoxide poisoning, asbestos, radon and cooking fumes. However, these are problems that are either too difficult to investigate (e.g. hazard from low levels of airborne asbestos fibres), or that are not so frequently encountered (e.g. cooking fumes in unventilated kitchens) in countries where research facilities and resources are most readily available. Hence, the journals are full of papers about the relatively trivial health effects which go to make up the so-called sick building syndrome seen in centrally-heated, air-conditioned offices in rich Western countries, but they devote little space to the really serious and widespread health problems associated with indoor air pollution in poor, undeveloped, or developing countries. A recent leading article in the Lancet (1990) is exceptional in this regard.

Table 2 lists what I consider to be the most serious and widespread health problems associated with the indoor environment. Not included in the list are various volatile organic compounds (VOC) derived from furnishings and fabrics, or ozone derived from copying machines in offices. Although such pollutants render the indoor environment smelly and unpleasant, there is little evidence that they give rise to serious adverse health effects. Also, not included in the list, is environmental tobacco smoke since, qualitatively, the pollutants generated by smoking are similar to those generated by stoves and ovens and, quantitatively, the contribution of tobacco smoke gases and particles to indoor air pollution is, in most situations, relatively small.

Cooking and Heating Fumes: Chronic Lung Disease and Lung Cancer

World-wide, cooking and heating fumes derived from high biomass fuels in poorly ventilated, or wholly unventilated, kitchens and houses are more strongly, and more widely, associated with high incidences of chronic lung disease (emphysema, chronic bronchitis, cor pulmonate) than any other factor. This may be deduced from the paper by Chen et al (1990) which was published in World Health Statistics Quarterly. Exposure to cooking and heating fumes is also associated with an increased risk of development of lung cancer. Thus, Chen et al cite evidence from a Chinese study that there is a ten-fold higher risk of lung cancer among non-smoking women who cook with coal stoves, than among non-smoking women who cook with gas stoves. Nor are these the only kinds of risk from cooking and heating fumes. In an area of China where the coal burnt has a high fluoride content, fluorosis is common.

Table 2. Most serious risks to health associated with the indoor environment

Death	**Source**
CO poisoning	Heating and cooking fumes
Emphysema & chronic bronchitis	
NOx SO_2 Aldehydes Other irritants Particles	Heating and cooking fumes
Lung cancer	
Radon PAH Asbestos, erionite Other	The earth, building materials Heating and cooking fumes Local mining, building materials ?Keeping of pet birds
Atopic symptoms	
Allergic moulds, fungi, mites, pets. Danders, feathers etc.	Damp, poorly-constructed, poorly-maintained dwellings. Offices with poorly-designed, and/or poorly-maintained heating and air-conditioning systems.
Respiratory and other infections	Airborne transmission of viruses and bacteria from person-to-person (eg by sneezing), especially with overcrowding.
KEY: CO = Carbon monoxide NO_x = Oxides of nitrogen SO_2 = Sulphur dioxide PAH = Polycyclic aromatic hydrocarbons	

Radon

In certain regions of the world's crust, there exist rock formations which emit radon gas, and this breaks down after a short half-life into more persistent radioactive radon daughters. For people walking around in such regions, the exposure to radon daughters is too low to have any measurable impact on their health. However, problems can arise in partly sealed buildings, such as centrally-heated, air-conditioned, ranch-type homes. If radon seeps into the air of the basement of such a house, and if this air is then heated and circulated throughout the house, dangerous levels of exposure to radioactive radon daughters can occur. In the United States, estimates of the numbers of cases of lung cancer attributable to exposure to radon range up to 40,000 deaths per year, although a figure closer to 5,000 is probably more realistic. The extent to which radon and its daughters in indoor air constitute a lung cancer hazard in poorer countries, and in the absence of mechanical heating/ventilation systems, is presently unknown.

Asbestos

Occupational exposure to airborne asbestos fibres constitutes a serious risk for the occurrence of two forms of cancer: cancer of the lung, and cancer of the pleura (i.e. mesothelioma). Cancers may arise even when exposure is not heavy enough to cause the fibrotic disease of the lungs known as asbestosis. On the other hand, gloomy predictions, made some 10-20 years ago, that we were heading for a huge epidemic of lung cancer and mesothelioma arising from the almost universal exposure of people to indoor and outdoor air contaminated by low levels of airborne asbestos fibres, have not been fulfilled. The consensus view now is that although many buildings, including domestic dwellings, include asbestos-containing materials in their construction, there is no danger from these unless they start to erode, and to release inhalable fibres into the atmosphere. It is almost certainly safer to leave such materials in place than to try to remove them, since damage to them during the removal process is likely to render the fibres airborne. Where buildings containing asbestos (e.g. as fire-proofing, or for thermal insulation) have to be demolished or renovated, then this should be seen to be a task for specially-trained, and properly-protected, workers. Otherwise, the most important precautionary measure is to educate people not to drill into, or saw, asbestos, and to seal with paint any asbestos surface which is flaking or disintegrating.

Carbon Monoxide

Deaths and disablements from incurable neurotoxicity occur all over the world as a consequence of carbon monoxide poisoning. Before coal gas, which contains carbon monoxide, was replaced by natural gas, suicide (e.g. by sticking one's head into an unlit gas oven) was common in countries such as Britain. Running one's car in a sealed garage is now the more common method. Accidental carbon monoxide poisoning, always has been, and still is, an all too common problem. One reason for this, is that the gas is odourless and non-irritant. It is produced during the pyrolysis of organic material, and is present, therefore, in almost all kinds of smoke, including that from tobacco, coal, wood and incense, and in the exhaust fumes of motor vehicles. Its toxicity depends on its having a much higher affinity than oxygen for haemoglobin, and it kills by asphyxiation. Fortunately, its binding to haemoglobin is reversible, so that blood levels of carbon monoxide fall when those who have been exposed to it are given fresh air to breathe. The rate of loss of carbon monoxide from the blood is higher during exercise than during sleep. Unapparent cracks in chimneys and exhaust ducts which allow carbon monoxide to enter living areas, particularly bedrooms, are responsible for many deaths in countries all over the world. The worst problems, however, arise in countries, such as Korea, where houses are heated by the burning of high biomass fuels, immediately under the floors on which people sleep. If hairline cracks develop in the flooring, enough carbon

monoxide can seep through to severely poison, or kill, the sleepers, who remain blissfully unaware of the danger.

Upper Respiratory Infections

Upper respiratory infections are much more readily transmitted from person to person inside buildings, or public vehicles, than out of doors. Such infections have a larger impact on health than any other factor in the indoor environment. For the most part, such infections are not serious; however, they are unpleasant, they lead to absenteeism from work, and they impair people's concentration and efficiency while working. Furthermore, in old and frail people, upper respiratory infections can lead to more serious complications, such as pneumonia, and even death. Transmission is facilitated by the proximity of people to each other. The generation of airborne aerosols through sneezing is the most important factor. Cotton masks provide little protection. Except in the case of influenza viruses, of which there are only a few serotypes, immunization is not a practical option. Over 200 antigenically-different viruses of other kinds can cause colds and other respiratory tract infections. Some of the symptoms caused by these virus infections are similar to those caused by chemical irritants and, indeed, the symptoms of people with upper respiratory infections tend to be made worse by airborne chemical irritants. Some of the viruses involved (e.g. the influenza viruses) have a protective lipid envelope. These are more stable in dry air. By contrast, viruses with no protective envelope (rhino and adenoviruses) are more stable in humid air. All viruses are more stable at low temperatures than at high temperatures. The high stability of influenza viruses in cold, dry, air explains why influenza epidemics occur predominantly in the wintertime. The best that one can presently hope to do, apart from prophylactic immunization in the case of impending influenza epidemics, is to try to avoid overcrowding within offices, and for the public to stifle sneezes, or only to sneeze into very carefully folded handkerchiefs, etc.

CONCLUSIONS

Climate and wealth are the main determinants of which aspects of the indoor environment impact most on health. In poor, hot, countries, the quality of the outdoor environment is usually the most important single factor. In poor, intermittently cold, countries, lack of ventilation for cooking and heating fumes is paramount. In rich countries, problems arising because of the poor design and/or maintenance of central-heating/air-conditioning systems, or because of the use of new fabrics/building materials, head the list. There is much more research carried out on the problems that arise in the rich countries than on the - often far more serious - problems that occur in poor countries and, there is a

danger that regulations based on research in rich countries is assumed to be relevant to, and appropriate for, poor countries where circumstances are quite different. A main aim of the present conference should, therefore, be to emphasize that research priorities and regulations should be based on a careful assessment of the main problems which occur in the particular region of concern, rather than being derived from countries with quite different climates and levels of personal wealth.

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