EFFECTS OF CLIMATE CHANGE

ON

TUBERCULOSIS TRANSMISSION

BY

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DEDICATION

This work is dedicated to the memory of the great Mainumatu who passed away on 7 November, 1999.

APPROVAL SHEET

This is to certify that this dissertation has been thoroughly criticized and approved as having fulfilled partial requirements for the award of Post-Graduate Diploma (PGD) in Environmental Management by Geography Department, Federal University of Technology (FUT) Minna.

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ABSTRACT

This thesis is aimed at finding likely or possible effects of climate change on human health in general and Tuberculosis in particular.

Anthropogenic factors responsible for climate change were highlighted.

Various changes the global climate had undergone at various times were examined as well as their consequencies on not only underdeveloped countries, but also the developed ones. Efforts made by countries on national or international, individual or collective level were examined.

Natural harzards exacerbated by climate change and their places of occurance were brought in focus. In addition, incidences of effects like heat waves, cerebro-spinal meningitis, etc, were shown to be affected by climate change.

Statistical data from Barau Dikko Specialist Hospital Kaduna on disease pattern was compared with statistics obtained from Kaduna State TB & Leprosy Control Programme office and it was found that TB is generally on the increase by several hundreds fold as against relatively stable pattern of other diseases.

LIST OF ABBREVIATIONS

1	-	AD	-	Anno Domini (in the year of the Lord)
2	-	AHRTAG	-	Appropriate Health Resources & Technologies Action Group.
3	-	AIDS	-	Acquired Immune Deficiency Syndrome.
4.	-	CFC	-	Chlorofluorocarbon
5.	-	CO_2	-	Carbon Dioxide
6.	-	CH_4	-	Methane
7.	-	EC	-	European Commission
8.	-	Eg	-	Exempli gratia (for example)
9.	-	ENSO	-	El Nino/Southern Oscillation
10.	-	FUT	-	Federal University of Technology
11.	-	GSS	-	Government Secondary School
12.	-	HBFC	-	Hydrobromofluorocarbon
13.	-	HCFC	-	Hydrochlorofluorocarbon
14.	-	HIV	-	Human Immunodeficiency Virus
15.	-	IPCC	-	Intergovernmental Panel on Climate Change
16.	-	IUATLD	-	International Union Against Tuberculosis & Lung Diseases:
17.	-	KDTBLCP	-	Kaduna State Tuberculosis & Leprosy Control Programme
18.	-	LGA	-	Local Government Area
19	-	LGSC	-	Local Government Service Commission
20	-	MDR-TB	–	Multidrug Resistant Tuberculosis
21	-	N_2O	-	Nitrous Oxide
22	-	NTBLCP	-	National Tuberculosis & Leprosy Control Programme
23.	-	NWRT	-	National Water Resources Institute
24.	-	PGD	-	Post-graduate Diploma
25.	-	PPB	-	Parts per billion by volume
26.	-	PPM	-	Parts per million by volume

27.	-	PTB	-	Pulmonary Tuberculosis
28.	-	TB	-	Tuberculosis
29	-	TBL	-	Tuberculosis & Leprosy
30	-	UN	-	United Nations
31	-	UNEP	-	United Nations Environmental Programme
32	-	UNICEF	-	United Nations Children's Emergency Fund
33	-	USA	-	United States of America
34.	-	UV	-	Ultraviolet Rays
35.	-	WMO	-	World Meteorological Organisation
36.	-	WHO	-	World Health Organisation.

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CHAPTER ONE

INTRODUCTION

"Throughout human history, the major problems of health that men have faced have been concerned with community life for instance, the control of transmissible disease, the control and improvement of physical environment the provision of water and food of good quality an in sufficient supply, the provision of medical care and the relief of disability and destitution. The relative emphasis placed on each of these problems has varied from time to time, but they are all closely related and from them, has come public health, as we know it today".

The sustained health of human population requires continued integrity of earth's natural systems. The disturbance, by climate change, of physical (eg, whether patterns, sea level, water supplies) and of ecosystems (eg, agroecosystems, disease –vector habitats) would therefore pose risk to human health. The anticipated health impact is that of whole communities or populations (ie, it is a public health, not a personal health, issue). These health impacts would occur in various ways, via pathways of varying directness and complexity, including disturbance of natural and managed ecosystems.

Populations with different levels of natural, technical, and social resources would differ in their vulnerability to climate induced health impact. Such vulnerability, due to crowding, food in-security, local environmental

degradation, and perturbed ecosystems, already exists in especially many communities in developing countries.

Many of the health impacts of climate change would occur via processed that are relatively unfamiliar to public-health science. They would not occur via the familiar toxicological mechanisms of localized exposure to environmental contaminants nor via locally determined influences on the spread of infectious diseased instead, many of the impacts would arise via the indirect and often delayed effects of disturbances to natural systems and their associated ecological relationships.

Climate change may, via various processes, exacerbate those ecosystem disturbances. Because an ecosystem comprises a suite of interacting components, in which member organisms relate to the whole suite rather than to individuals part, the uncoupling of relationship by climate change could initiate a cascade of disturbances that might jeopardize human population health. Indeed, recent global and regional climate events may have contributed to some of the increase observed in the incidence of new and recurrent infectious diseases.

With the aforementioned problems of climate change, I set to examine the likely impact/effects of climate change on tuberculosis (TB) transmission on public health scale in Nigeria, the international traveler that does not need visas, that does not even recognizes boundaries, nor does it discriminate races or tribes, or the young from the old. Infact, TB is currently the single

biggest infectious killer of youth and adults, causing between 2 to 3 million deaths each year, worldwide.

The sustainability of human population health is, of course, a fundamental important criterion of successful social and economic policy. As such, it is an essential component of sustainable development as expressed , in Agenda 21, adopted at the United Nations Conference on Environment and Development in 1992.

STATEMENT OF PROBLEM (HYPOTHESIS)

1- Climate change accelerate speed/spread of TB bacilli in the air.

2- Stressful weather and polluted air combined will exacerbate TB infection.

3- Climate change will affect food supply, which will in turn lower nutritional status of individuals thus more prone to TB infection.

IMPORTANCE OF STUDY

1- To make health a valued public asset.

2- Highlight dangers associated with excessive emission of greenhouse gases to the atmosphere.

3- Highlight dangers tuberculosis (TB) is posing to human populations.

4- Draw attention of governments on possible economic implications/burden TB might cause to the public.

LIMITATIONS AND SCOPE

The thesis consists of two main parts – climate change and tuberculosis, each of which volumes and volumes can be written on. This, however, was

not made possibly by numerous factors like time taken to gather relevant information on any of these, money involved in doing that (collecting the data), instruments and personnel, to mention a few.

For this therefore, I confined myself to write on the selected topic, and solely relied on data from the record office of Barau Dikko Specialist Hospital Kaduna and that from Kaduna State TB and Leprosy Control Programme office Kaduna. Infact, data from the first source were only obtained after I got introductory letter from Dr. Emmy van der Grinten, the KDTBLCP Officer.

LITERATURE REVIEW

Globally, evidences from paleoclimatology have indicated that during the Ice Ages (about 2.5 million to 10,000 years ago), global temperatures were about 5^0c (which is lower than now). There was further warming until about some 7000 years ago, when the earth was 2^0c warmer than the present; this period is referred to as the Althithermal period. The years between Althithermal period to about 1000AD, was observed to further reduce in temperature. But by 1000AD, there was another thermal period popularly known as the medieval warm Epoch, before the little Ice Age, which persisted with about a degree cooling until 1650AD. Since then, there has been persistent warming with few period of cooling interruption (Adeyemi, 1992).

Earth's climate has remained relatively stable (global temperature changes of less than 1^0c over a century) during the last 10,000 years (the present interglacial period). Over this period, modern society has evolved and in many cases, successfully adopted to the prevailing local climate and its

natural variability. Now, however, society faces potentially rapid changes in future climate because of human activities that alter the atmosphere's composition and change the earth's radiation balance. (See figure 1 on page 5).

In Africa for example, Grove (1968, 1972), observed that the climate was drier than at present, particularly in lands now semi-arid or sub-humid; rainfall being a third of the present amount and temperature between 4-6^{0}c lower. The Sahara desert was smaller in size and Lake Chad bigger. Cultural, environmental and hydrological indicators, observed Nicholas (1989), all suggest that from Mauritania east-ward to Ethiopia, conditions significantly more humid than the current ones prevailed from the thirteenth century. At the end of eighteenth century, marked desiccation commenced over Africa. Lake levels evidenced these, landscape description, historical accounts and sporadic meteorological data. In about 1800 the level of the Nile flow became very weak, the level of Lake Chad fell, and droughts became a common occurrence (such as the Sahelian drought of 1968-1973 and that of 1982-1984). A relatively humid period persisted from 1870s to the mid 1890s, before conditions again changed abruptly around 1895, and a continent-wide decrease in rainfall culminated in a long period of severe droughts in the 1910s.

Significant depletions in stratospheric ozone concentrations have been recorded since 1977. The earth's atmosphere is warmed by the green house effect where short wavelength (ultraviolet) solar radiation reaches the earth's

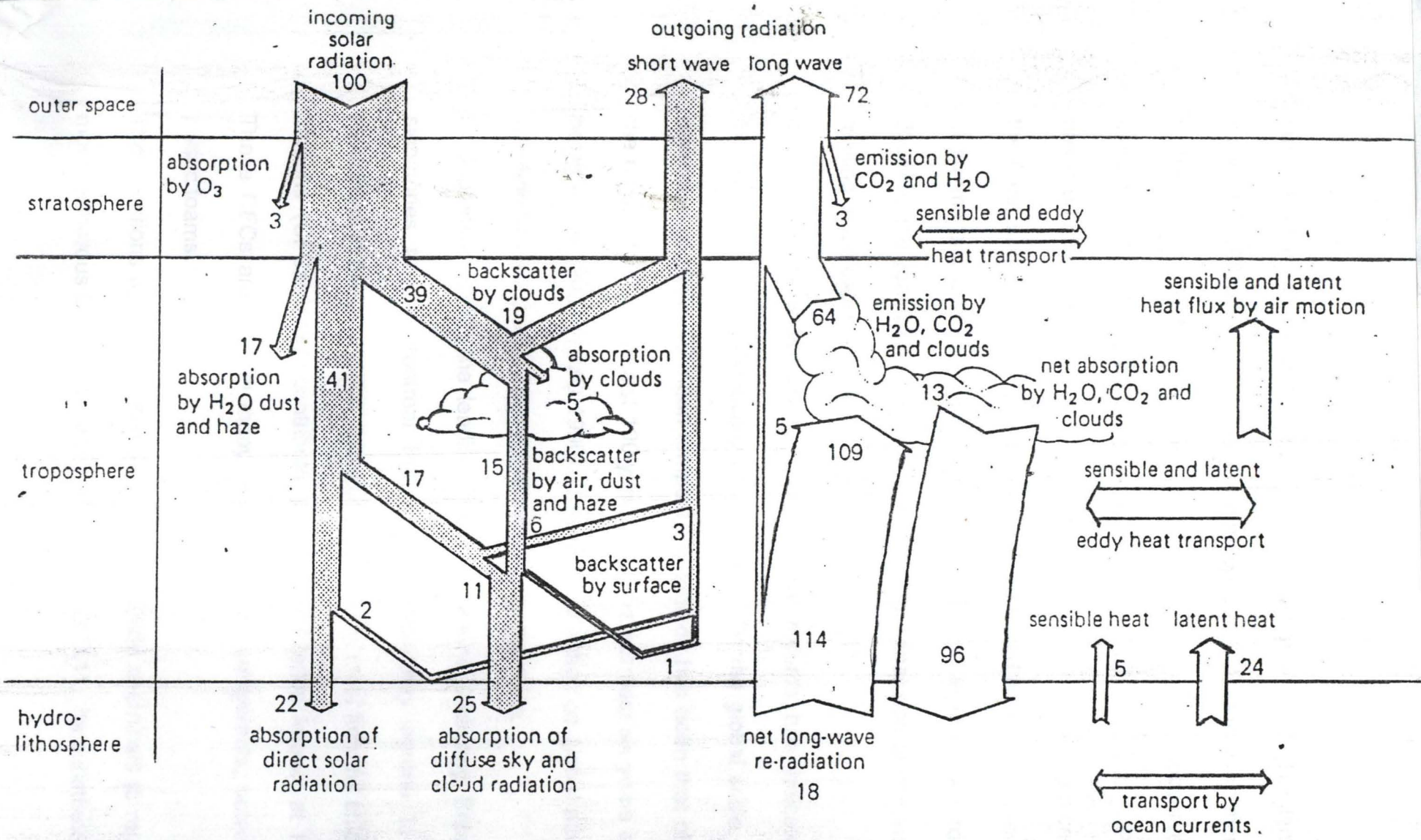

Figure 1 The earth's radiation balance between incoming (solar) radiant energy (on the left) and outgoing (terrestrial) radiant energy (on the right). The figure also shows the distribution of energy in the global system.

Source: Dictionary of Environmental Science & Technology by Porteous A.

22 which, although less toxic, all-the-same represents a considerable threat to ozone depletion. For example, it has been calculated that CFC-22 is about 20 times less harmful than CFC-11.CFC-11 has half-life of about 75 years compared to 20 years for CFC-22. Therefore, in the next 20-30 years from then (ie by year ,2007-2017) when the ozone layer will be most rapidly depleted, it is estimated that CFC-22 is likely to be only 20% as damaging as CFC-11. Infact, Peter Fabian of Max Planck Institute for Aeronomy, Gottnigen, believes that if CFC-22 is released into the atmosphere at this rate of that time, then it will have destroyed as much ozone as the two most common CFCs, CFC-11 CFC-12.

Though safer than CFC-11, CFC-22 is still harmful but was not included in Montreal Protocol 1987. Moreover, the wisdom of replacing one dangerous CFC with another that is perhaps cumulatively just as harmful should be questioned or re-examined seriously –something that indeed made the British government in early March, 1989, to convene an international conference on atmospheric ozone depletion, at which representatives from 124 other nations attended. Even before the conference opened, the European Commission (EC), USA, and Canada had agreed to a complete phasing out of the five CFCs, and three halons covered by the Montreal Protocol. The Protocol stipulated a 50% reduction in the production and consumption of these materials by last year (2000). This development was justifiably seen by the media and general public as a resounding success story.

Sequel to this, 81 nations met in Helsinki, in early May, 1989, to agree in principle, to ban eight industrial chemicals by last year (2000). These chemicals included five CFCs and three halon gases, as mentioned above. At this meeting Eileen Claussen, of the USA's Environmental Protection Agency, predicted that even if CFCs are totally phased out and banned by the turn of the twenty-first century, chlorine concentrations will still treble from that year's existing levels of 2.7-8.9 ppb by the year 2010, mainly because of time taken for CFCs to breakdown in the atmosphere. Therefore at an international meeting of parties to the Montreal protocol, in November 1992 in Copenhagen, revised controls on ozone depleting substances and the dead lines for the global phase-out for most chemicals was brought forward. The Copenhagen package consisted of the following agreement:

- For CFCs, the phase-out date was brought forward from January, 2000 to 1 January, 1996, with 75% reduction, based on 1986 levels, by 1 January 1994. The EC has proposed an interim 85% reduction by 1 January 1994.
- Carbon tetrachloride should be phased out by January 1996 rather than 2000 as originally proposed, with an 85% reduction based on 1989 levels, by 1 January 1995. The EC has proposed interim 85% reduction by 1 January 1994.
- Halons should be phased out by January 1996, again brought forward from the January, 2000 target date. The EC has proposed a phase-out by January 1994.

- Methyl chloroform should be phased out by January 1996, brought forward from January 2005, with 50% reduction on 1989 levels by January 1994. However, the of halons may continue beyond the new proposed phase-out dates, and a United Nation Environmental Programme (UNEP) panel will prepare an assessment of such essential usage, with the announcement of a decision scheduled for 1994.
- Methyl bromide consumption is to be pegged at 1991 levels by 1995. More stringent controls must await scientific evaluation by two UNEP panels which are scheduled to report in 1995.
- HBFCs, although not in general use, should be phased out by January 1996. This is the first time that HBFCs have come under any control.
- HCFC use is to be capped in January 1996 at a level amounting to the sum of their consumption in 1989 and 3.1% of the level of consumption of CFCs in 1989. This formula arose in order to take into account the then exiting consumption of HCFCs which were already high in some countries in 1989, and also in recognition of their role as transitional substitutes for CFCs. The Copenhagen amendments incorporated controls for the first time on HCFC use, which is to be phased down to a 35% reduction of the 1996 consumption level by year 2004, by a 65% reduction by 2010, and a total ban by 2030.
- In February 1991, the US government proposed a strategy to limit global greenhouse warming by suggesting that nations should seek comprehensive framework for the emission of greenhouse gases in

preference to focusing on a simple gas. This led the United Nations Framework Convention on Climate Change 1992, to adopt US government's suggestion.

Campbell and Ericksen (1990), predicted that global warming could trigger a cascade of natural hazard effects, both directly through the meteorological processes associated with climate change, and indirectly because of rising sea level (See fig. 2 below).

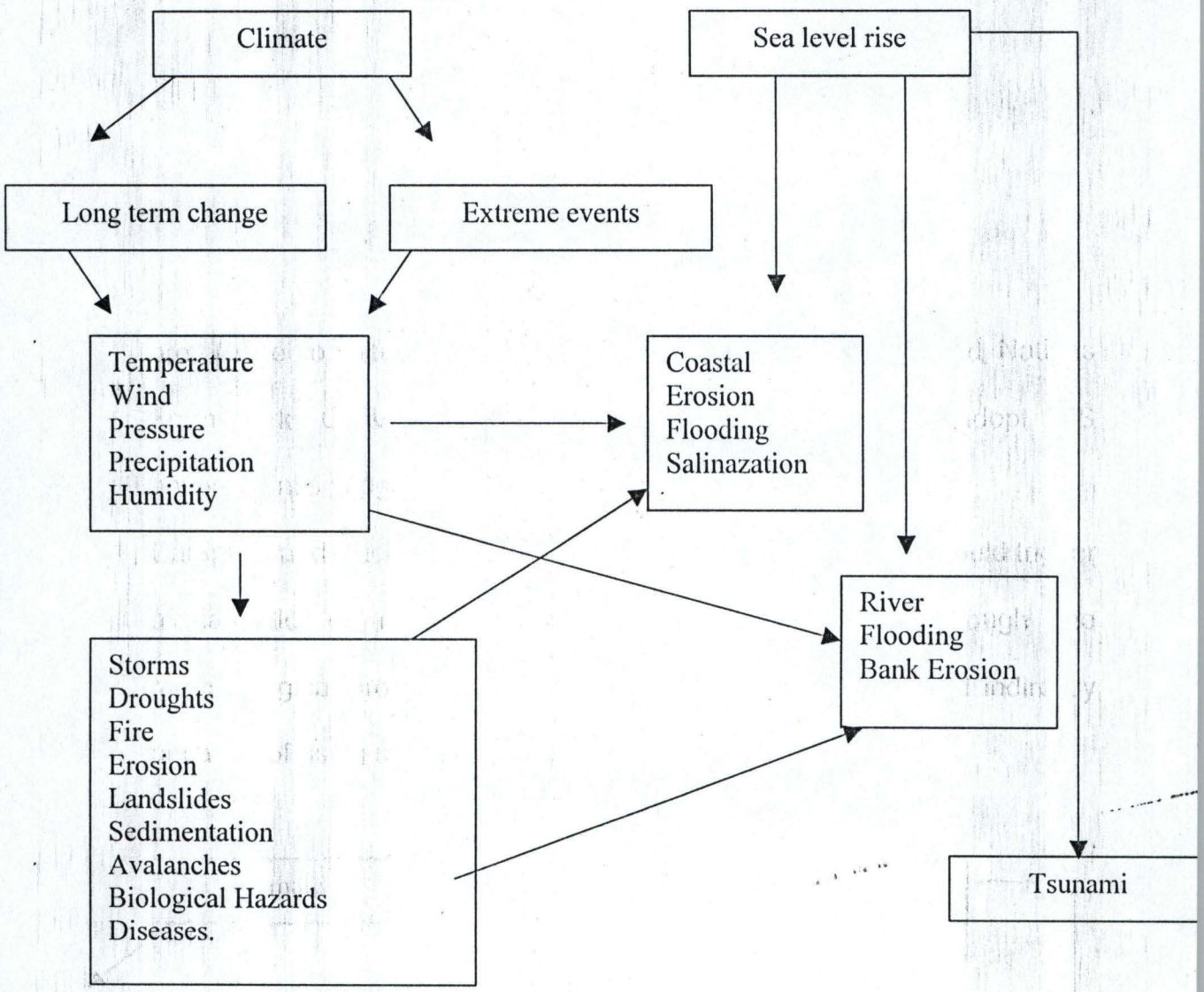

Figure 2: Global warming may trigger a cascade of hazard effects both directly through mechanism of climate change and indirectly via sea level rise (Campbell & Ericksen, 1990).

The potential health implications of climate change were first addressed by World Health Organisation (WHO) in 1990, with the publication of a short document titled, `Potential health effects of climate change' (WHO/PEP/90.10), prepared with assistance from World Meteorological Organisation (WMO).

Consideration progress has been made in the understanding of climate change science since 1990 and new analysis and data have been made available by Intergovernmental Panel on Climate Change (IPCC) working groups I, II, & III. IPCC charged working group II to review current (1994) knowledge about the impacts of climate change on physical and ecological systems, human health, and socioeconomic sectors. IPCC also asked working group II to review the then available data on technical and economic feasibility of a range of potential adaptation and mitigation strategies. In proceeding its report, working group II has co-ordinated its activities with those of working Groups I and III, and built on the 1990 and 1992 assessments.

"The earth's climate has remained relatively stable (global temperature changes of less than 1^0c over a century) during the last 10,000 years (the present interglacial period). Over this period, modern society has evolved through science & technology and, in many cases, successfully adopted to the prevailing local climate and its natural variability. Now, however, society

faces potentially rapid changes in future climate because of human activities that alter the atmosphere's composition and changes the earth's rediation balance", reported IPCC Working Group II.

It went further to state that atmospheric concentrations of green house gases (which tend to warm the atmosphere) and aerosols (which in some regions partially offset the green house effect) have increased since the industrial era began around 1750.

Carbondioxide (CO_2) has risen by about 30%, methane (CH_4) by 145%, and nitrious oxide (N_20) by about 15%. These gases are now at greater concentrations than at any time in the past 160,000 years (the period for which scientists can reconstruct historical climates and atmospheric compositions by analyzing ice-core data). $C0_2$ has contributed about 65% of the combined radiative effects of the long-lived gases over the past 100 years; CH_4 and N_20 have contributed about 20 and 50%, respectively.

Climate changes and their effects on food security, water supply and quality, and the distribution of ecological systems may have wide ranging and potentially adverse effects on human health, via both direct and indirect pathways (see figure 3); it is most likely that the indirect impacts would , in the longer term, predominate.

Mediating Process	Health Outcomes
DIRECT	
Exposure to thermal extremes (especially heatwaves)	Altered rates of heat-and cold-related illness and death (especially cardio-vascular and respiratory diseases)
Altered frequency and/or intensity of other extreme weather events (floods, storms. Etc)	Deaths, injuries, and psychological disorders; damage to public health infrastructure
INDIRECT	
DISTURBANCES OF ECOLOGICAL SYSTMES Effects on range and activity of vector and infective parasites	Changes in geographic ranges and incidence of vector-borne disease.
Altered local ecology of water-borne and food-borne infective agents	Changed incidence of diarrheal and certain other infectious disease.
Altered food (especially crop) productivity due to changes in climate, weather events, and associated pests and diseases	Regional malnutrition and hunger, and consequent impairment of child growth and development
Sea-level rise, with population displacement and damage to infrastructure (e.g., sanitation)	Injuries, increased risks of various infectious disease (due to migration, crowding, contamination of drinking water). Psychological disorders
Levels, and biological impacts of air pollution, including pollens and spores	Asthma and allergic disorders; other acute and chronic respiratory disorders and deaths
Social, economic, and demographic discolcations due to adverse climate change impacts on economy, infrastructure, and resource supply	Wide range of public health consequences (eg. Mental health, nutritional impairment, infectious diseases, civil strife)
	Skin cancers, Cataracts, and perhaps immune suppression; indirection impacts via impaired productivity of agricultural and aquatic systems

Fig 3: possible major types of impact of climate change and stratospheric ozone depletion on human health.

Source: World Health Organization.

However, the extent of climate-induced health disorders depends on numerous co-existent and interacting factors that characterize the vulnerability of a particular population. These include environmental circumstances (such as water purity) and socio-economic factors (such as nutritional and immune status, population density, and access to health care). Direct health effects include increases in heat-related (predominately cardiorespiratory) mortality and illnesses resulting from an anticipated increase in the intensity and duration of heat waves; "heat waves killed more 800 people in the American Mid-west", reported Newsweek, January 22,1996. In Chicago, USA, over 500 excess deaths were recorded in 1995. During various heat waves in India in 1995 and 1998, it was estimated that the number of excess deaths rose by several thousands. A record-breaking heat wave during June 1998 in central Russia caused more than 100 deaths (WMO) 1999. In Nigeria, outbreaks of cerebral meningitis have, in recent years, led to fatalities during the dry hot season. Studies in some selected cities in parts of the world in North America, North Africa, and East Asia indicate that the annual numbers of heat-related deaths would increase several-fold in response to climate change projections. Temperature increases in colder regions should result in fewer cold related deaths.

In Nigeria for example, Adefolalu (1984) was able to show that the effect of harmattan dust on human health was not much of a problem before 1975. At Akure, in 1981/82, when about 45% of annual cases of respiratory problems occurred during the harmattan season, the monthly totals of in-patients were 70 and 88 in February and March 1982 and a total number of in-and out-patients ranged between 36 and 177 per month during the period. In Warri, available medical records for November to March of the harmattan season of 1977 to 1980 gave an average of between 27 and 63 in-patients per month over the three-year period. But for 1977/78 session when information was complete, the harmattan season accounted for about 42% of the twelve-months total between April 1977 and March 1978. He went further to state that that was high, especially when it is realized that the commonest respiratory infections (pneumonia and bronchitis) are associated with the rainy season when surface wetness and lower temperature are critical factors.

The incidence of deaths, injuries, psychological disorders, and exposure to chemical pollutants in water supplies would increase if extreme weather events (eg, droughts and floods) were to become more frequent; and indeed, it did. In 1995 and 1996, 8,300 and 8340 lives were lost respectively to weather events (WMO, 1997). China lost about 2 million houses and over 2,000 boats sank.

El Nino is found to exert great global burden on natural disasters, especially on drought and related food shortages. It is also linked to world food crises

because it affects many countries at the same time (WMO, 1999). Rainfall anomalies in west Africa is also related to El Nino (Southern Oscillation (ENSO) events (Ogunkayode, et al 1999).

Increase in average annual temperatures of as much as 4^0c in Alaska, Siberia and parts of Canada have been recorded (TIME, 2000). The report went further to state that sea Ice is 40% thinner and covers 6% less area than in 1980. Permafrost is proving less permanent – 1.5km – wide lake had opened up at 90^0 North, with gulls fluttering overhead. Increase in the incidence of acute-diarrheal and respiratory diseases were recorded in Peru in 1983, after El Nino-related flooding. This country also experienced damage to about 10% of its health facilities, in addition to disruptions to power and water supplies and other transport systems. After 1997/98 El Nino, the riverine areas of Nigeria experienced epidemics of swine-fever.

Indirect effects include increase in the potential transmission of vector-borne diseases (eg, malaria, dengue, Chaga disease, yellow fever, and some viral encephalitis) caused by extension of the ranges and seasons of vector organisms. Climate change would also accelerate the maturations of certain infections parasites (eg. The malaria organism). Some increases in non-vector-borne infectious diseases such as salmonellosis, cholera, and other food and water-related infections could occur, particularly in tropical and subtropical regions because of climatic impacts on water distribution, temperature, and micro-organism proliferation.

There are other likely indirect effects, which include increases in asthma, allergic disorders, cardiorespiratory diseases, and associated deaths. These might result from climate-induced changes in pollens and spores, and from temperature increases that enhance the formation, persistence and respiratory impact of certain air pollutants.

Exposure to air pollution and stressful weather events combine to increase the likelihood of morbidity an mortality.

Despite great advancement in technology, sophistication in medical procedures in European countries, and of course its position on the globe and relatively low temperature, experience resurgence of TB (Tuberculosis). In London for example, an average of two deaths and 50 new cases are reported each week, in addition to incidence rate of 32 per 100,000 (see figure 4). In France, 40% of the country's approximately 10 per 100,000 reported TB cases are in the Paris region. Romania has a rate of 56 per 100,000 in 1985, but has 114 per 100,000 (up by more than double) or 200% by last year. Worst more, 7 people die and 74 contact it each day. There has been increase in incidence of 20% in Demark for 1986-92, 27% in Italy for 1988-92 and 28% in Spain for 1990-92. The US has a 20% increase for 1985-92 several sub-Saharan African countries have rate of 96.8 per 100,000 TB is one of the major causes of adult morbidity and mortality in the region and is responsible for large numbers of adult hospital admissions and hospital deaths. WHO reported that resistance to at least one TB drug has increased by 50% in both Demark and Germany since 1996.

In Russia, where 10% of the 1 million strong prison population is infected with TB, a third suffer from multi drug resistant TB (MDR-TB). The country is averaging 150,000 new cases annually. In year 2000, deaths due to TB rose by 30%. In Estonia, the incidence of MDR-TB increased nearly 5% from 1997 to 1998 to 18% of all TB cases. An outbreak of MDR-TB claimed more than 500 lives in New York City alone.

COUNTRY	INCIDENCE RATE PER 100,000 POPULATION
Sweden	5
Belgium	10
Germany	13
Spain	23
Portugal	53
Bulgaria	55
Estonian	57
Latin	81
Lithuania	82
Romania	114
Nigeria	243

Figure 4: TB rates per 100,000 people in some European countries and Nigeria.

Sources: TIME magazine & NTBLCP's Guide for Medical Officers.

CHAPTER TWO

EPIDEMIOLOGY OF TUBERCULOSIS

Over 90 million people were thought to have developed TB worldwide in the last decade. One-third of this number are expected to die in the next decade. Already, an estimated 50 to 100 million people in the world may have been infected with multi drug resistant TB (MDR-TB). A third of the world's population is infected with tuberculosis and one out of five adults in developing countries die of TB. Despite the development of effective anti-tuberculosis drugs, TB causes more deaths than any other infectious disease – that is to say TB is the biggest infectious killer the world over. Nigeria is estimated to have about 259,000 TB cases and incidence rate of 243 per 100,000, out of which 113,000 are smear positive, with a rate of 106/100,000.

WHAT IS TUBERCULOSIS?

Tuberculosis is an infections disease caused in most cases by micro-organisms called mycobacterium tuberculosis. The bacteria enter the body by inhalation through the lungs. They spread from the initial location in the lungs to other parts of the body via the blood stream, the lymphatic system, via the airways or by direct extension to other organs.

Basically, there are two types of TB- the Pulmunary TB and the Extra-pulmunary TB. The former is the most common form of the disease which may be infectious. Extra-pulmunary TB affects organs other than the lungs (thus the name, extra-pulmunary), most commonly pleura, iymph modes, spine, joints, genitourinary tract, nervous system, abdomen, etc.

INFECTION AND DISEASE.

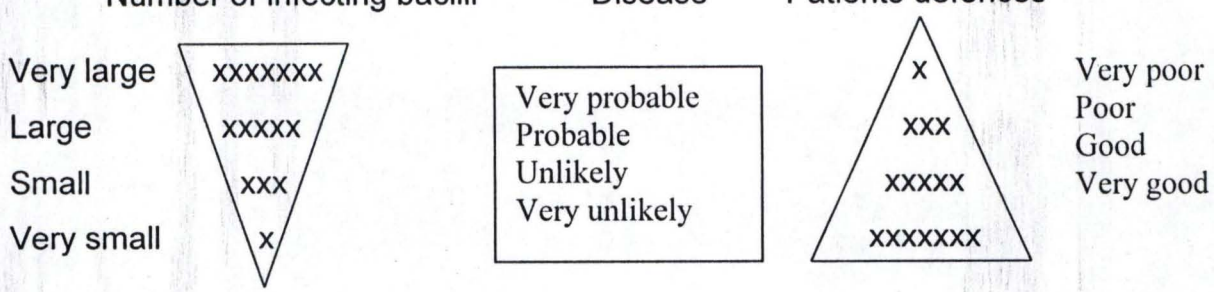

Fig: 5: Probability of developing tuberculous disease. The influence of the number of infecting bacilli and strength of the patient's defenses. (Crofton, Horne, & Miller 1992).

From the above figure it can be understood that whether infection develops to disease depends mainly on:

(i) The size of the infecting dose, or number of TB bacilli inhaled

(ii) The defences of the person infected, or the strength of the immune system of an individual.

TRANSMISSION OF INFECTION

Transmission occurs by airborne spread of infectious droplets. The source of infection is a person with PTB and is not on medication. This is usually a smear positive on sputum examination. Coughing produces tiny infectious droplets (droplet nuclei). One cough can produce as many as 3,000 droplet nuclei. Transmission generally occurs indoors, where droplet nuclei can stay in the air for a long time. Ventilation removes droplet nuclei. Direct sunlight quickly kills tubercle bacilli, but they can survive in the dark for several hours.

Two factors determine an individual's risk of infection; the concentration of droplet in contaminated air and the length of time he breathes that air.

RISK OF PROGRSSION OF INFECTION TO DISEASE

Once infected with mycobacterium tuberculosis, a person stays infected for many years, or even probably for life. But the vast majority of persons infected (about 90%) without HIV infection do not develop tuberculosis disease. In these healthy, asymptomatic, but infected individuals, the only evidence of infection may be a positive tuberculin skin test (Mantoux test). However, positive Mantoux test does not indicate an individual has TB disease, but is only infected with the bacilli.

Infected persons can develop tuberculosis at any time. The chance of developing disease is greatest shortly after infection and then gradually lessens afterward. Various environmental or emotional stresses may trigger progression of infection to disease. The most important of which is weakened immune resistance, especially by HIV infection or UV rays. Disease can affect most tissues and organs, but especially the lungs.

NATURAL HISTORY OF UNTREATED TB

Without treatment or proper indication, and/or good nutrition after 5 years, 50% of pulmonary tuberculosis (PTB) patients will die, 25% will develop very strong immunity and be healthy (self-cured), and 25% will remain ill with chronic, infectious tuberculosis.

FACTORS AFFECTING TRANSMISSION OF TB

As mentioned in the introductory part of this thesis, tuberculosis, "the consumption, affects both male or female, young or old. But one thing that is certain is that infants and young children are more susceptible to the most fatal forms of TB, military tuberculosis and tuberculous meningitis.

i. **Nutrition**: There is very good evidence that starvation or malnutrition reduces resistance to the disease. This is a very important factor in especially poorer communities, both in adults and in children.

ii. **Toxic factors:** Tobacco smoking and high alcohol intakes are very important in reducing body defences. Same holds for corticosteriod drugs and other immune suppressants used for treating certain diseases.

iii. **Poverty**: This leads to bad and overcrowed housing or poor work conditions. These may lower defences as well as making infection more likely. People living in such conditions are often also badly nourished. The whole complex of poverty makes it easier for the TB to cause disease.

iv. **Other diseases**: In many countries HIV infection is now far the most important. The damage to the body's defences frequently results in complication by tuberculosis (30-60% of HIV infected persons develop TB). Tuberculosis is also liable to occur in patients with diabetes, leukemia or leprosy. Miliary tuberculosis may follow HIV infection,

measles, whooping cough or other acute infections in children. Chronic and worm infestations may be particularly important in the tropics.

SIGNS AND SYMPTOMS OF TUBERCULOSIS (PTB)

Signs

i. Patients appear ill, thin, and pale or flush.

ii. Fever

iii. High pulse rate

iv. Fine crepitations (crakles) on the upper part of one or both lungs, which may progress to dullness to percussion or even bronchial breathing in the upper part of both lungs.

v. Occasional finger clubbing.

(b) Symptoms.

i. Respiratory

... Cough for more than three weeks

... Sputum production

.. Blood spitting (haemoptysis)

. Chest wall pain

. Breathlessness

. Localized wheeze

. Frequent colds

ii. General

... Loss of weight

.. Fever and sweating in the nights

.. Tiredness

. Malaise

. Loss of appetite

(The number of dots show which symptoms are most important).

CHAPTER THREE

METHODOLOGY

Data for this work were obtained from two sources – medical records office, Barau Dikko Specialist Hospital, Kaduna, and Kaduna State TB & Leprosy Control Programme Headquarter, Kaduna. Since it is a known fact that medical records are kept in very high secrecy, access to data at from the first source was only possible after I presented an introductory letter from the Kaduna State Tuberculosis and Leprosy Control Officer, in person of Dr. Emmy van der Grinten. From the OPD registers presented to me (ie for 1996-2000), I extracted the information I needed for comparision and analysis with what was obtained at KDTBLCP office. However, it must be stated that the first source was chosen as it is one of the most busiest health center in Kaduna state year-in, year-out.

For each year stated above, total number of patients registered was compared with number of registered respiratory problems and percentage was taken. Thereafter, total respiratory problems registered for each year was compared with harmattan period numbers for which percentage was taken as well. Next, come comparison between general disease pattern with TB pattern. And finally, TB statistics for the whole period was analysed.

DATA PRESENTATION

Table 1: Number of in and out-patients registered (general disease) at Barau Dikko Specialist Hospital, Kaduna, 1996-2000.

YEAR	GENERAL DISEASE	RESPIRATORY PROBLEMS	PERCENTAGE
1996	40878	2852	7.0%
1997	30749	3017	9.8%
1998	15221	2624	17.2%
1999	13485	2936	21.77%
2000	15042	3785	25.16%
Total	115375	15214	13.18%

Table 2: General respiratory problems registered at Barau Dikko Specialist Hospital Kaduna against harmattan period cases for 1996-2000.

YEAR	REGISTERED RESPIRATORY PROBLEMS		PERCENTAGE
	YEARLY	HARMATTAN PERIOD	
1996	2852	1748	61.3%
1997	3017	1810	60.0%
1998	2624	1650	62.9%
1999	2936	1861	63.4%
2000	3785	2165	57.2%
Total	15214	9234	60.7%

Average for the period = 60.96%

Table 3: General disease pattern reported at Barau Dikko Specialist Hospital Kaduna and TB pattern registered by Kaduna state TBL control programme for 1996-2000.

YEAR	GENERAL DISEASE	TB CASES	PERCENTAGE
1996	40878	414	1.01%
1997	30749	340	1.11%
1998	15221	665	4.37%
1999	13485	1966	14.58%
2000	15042	2995	19.91%
Total	115375	6380	5.53%

Table 4: TB statistics for Kaduna state for the period 1996-2000

EAR	NEW		RELAPES	FAILURE	EXTRA-PULMNARY	DIED
	SMEAR POSITIVE	SMEAR NEGATIVE			TB	
996	333	42	24	6	9	5
997	205	107	16	7	5	16
998	479	132	27	18	9	12
999	1204	575	59	55	73	38
000	2068	717	63	70	77	180
tal	4289	1053	189	156	173	251

DATA ANALYSIS

Looking at column 2 of table 1, one will observe that the number of cases registered has drastically reduce from 40878 to 13485, corresponding to 67.01% decrease during the period 1996-1999, though the number has slightly increased to 15042 in the year 2000, corresponding to an increase of 11.55%. Despite a drop in number of respiratory cases of 3017 to 2624 in 1997 and 1998, there is a general increase for 32.71% for the period under observation (1996-2000).

An instant look at table 2 will send a chilling feeling through the spine as throughout the period under review, the least percentage of harmattan period respiratory cases reported was 57.2% and the highest 63.4% (that is to say it lays within a range of 55.0 – 65.0%). This range is too high on whatever scale one measures it, more especially if one considers the 60.7% of yearly total was in harmattan and the average for the period was 60.96%.

Table 3 shows that although there was an increase in number of cases by 11.55% between 1999 and 2000, the years preceding that saw a great reduction in number of cases of 67.01% (for general disease).

But for TB, the story is different. There was a drop in number of cases of 414 in 1996 to 340 in 1997, corresponding to a 17.87% decrease. What followed was rapid increase in number of cases from 340 in 1997 to 2995 in 2000, corresponding to 780.88% increase. This is extremely high especially that case detection is passive and expected number of TB patients is much, much higher than what was registered.

For tuberculosis alone, there has been a very, very sharp increase (or rather sharp upshot) in number of cases though not all active cases were detected as case finding was passive (ie only cases that make self-report were registered).

Points of special interest in this table (table 4) is the number of new smear positive cases, who as I mentioned earlier are part of source of infection in the community – other are relapse cases, as well as failure. Relapse cases are showing how TB is re-infecting ex-TB patients (its presence in the atmosphere and how weakened their immune systems has become). In 1996, there were only 24 relapse cases but in the year 2000, 63 cases were registered. When one expresses this increase in percentage one finds out that, there was an increase of 162.5%.

A similar or worst trend is observed for failure cases. This column is telling us that we have a very big problem in our hands as more and more tuberculosis patients are carrying multidrug resistant TB (MDR-TB) around. From just 6 cases in 1996, to 70 in the year 2000, corresponding to an increase of 1066.67%.

A 755.56% increase of extra-pulmonary TB was recorded under the period of study. This also, is showing the increasing deterioration of individual's immunity to TB infection that we have complicated or disseminated TB that is not confined to the lungs alone but to many other parts of the body. This, when found in children, may lead to permanent disability or death.

CHAPTER FOUR

SUMMARY

In an attempt to find out possible affects of climate change on tuberculosis transmission, this thesis went through memory lane to research findings of other researchers on effects of climate change, what is/are responsible for that (natural and anthropogenic) and its/their resultant consequences, especially on human health.

In this line, tuberculosis was examined in the context of its epidemiology, causative agent, its major types, how it is transmitted from one person to another, and the difference between its infection and disease.

Other aspects highlighted were natural history of TB, factors affecting its transmission, as well as its signs and symptoms. Finally, the thesis has briefly focused on the evidence of resurgence of TB in some well developed countries, including United States of America (USA), and Nigeria and Kaduna State, in particular.

FINDINGS

This thesis was able to find out that climate variability affects the incidence of respiratory problems in the harmattan period each year examined (1996-2000). Within this period examined, harmattan period accounted for about 57.2% - 63.4% of all respiratory problems registered at Barau Dikko Specialist Hospital, Kaduna. The number of smear-positive TB cases (registered by KDTBLCP) has sky-rockted from 333 in 1996 to 2066 in 2000, representing more than 600%. Similar or worst

trend was true for relapse, failure, and extra-pulmunary TB cases, as it was for TB cases who died.

CONCLUSION

The judgment that was drawn from the proceeding pages was that the hypothesis earlier mentioned (at the beginning of this thesis) were true because TB is the "biggest single killer of young people in the world" today, the most widely travelled disease the world over.

RECOMMENDATION

This section is arrived at giving some suggestions which are thought to be appropriate to reduce the impacts of climate change on human health in general and TB infection in particular.

1. Reduce greenhouse gas emissions and enhance sinks through:
    (a) Energy demand
    (b) Energy supply
    (c) Transportation
    (d) Industry
    (e) Land management
2. Policy formulations by governments to reduce green house emissions.
3. All future developments should revolve around sustainabie development.
4. Governments to improve its health care services at primary, secondary and tertiary levels.
5. There should be improvements in our buildings to give more ventilation.

6. Individuals should refrain from or limit dangerous exposures to any environment that brings ill health.
7. Improve large-scale monitoring and surveillance systems.
8. Observations and monitoring of earth's environment and ecosystems in relations to climate change should incorporate health related monitoring.
9. There should be development and practicing of early-warning systems techniques.

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GLOSSARY

The glossary is to explain some of the words used in this thesis. It is particularly meant for readers who are not professionals and those who are not yet very fluent in the English Language. Words often have more than one meaning. Here, I only try to explain the meaning they are used in the thesis.

1. Anno Domini :– In the year of the Lord; now used in numbering the years since Christ was thought to have been born.
2. Agroecosystem:- The ecosystem of an agricultural farm land.
3. AIDS: A health condition brought about by infection with a virus (HIV) which causes the body's immunity or immune system to become very weak, thus more vulnerable to infection from disease organisms.
4. Althithermal period: This is about 7,000 years ago when the earth was thought to be 2^0c warmer than the present.
5. Anthropogenic: Man-induced climate change.
6. Asthma: A chronic, sometimes hereditary disorder of the organs of respiration, which is characterized by difficulty breathing, wheezing (produce hissing sound on breathing), and a tightness or congestion in the chest.
7. Bronchitis: Expansion and inflammation of the mucus membrane of the bronchus as a result of infection or exposure to cold conditions for a long time.
8. Carbon Dioxide: It is an oxide of carbon which is colourless, odourless, and incombustible of gas, found in the atmosphere.

9. Carbon Tetrachloride: Written as CCl, it is a solvent made from carbon disulphate and chlorine.

10. Chaga's disease: A tropical disease transmitted by a parasitic micro-organism, Trypanosoma cruzi, and characterized by high fever and inflamunation & swelling of the muscles of the heart, spleen, liver, etc.

11. Chlorofluorocarbon: An alkaline in which chlorine and fluorine atoms have been substituted for hydrogen atoms, used in aerosols, refrigerants, etc, some of which are thought to attack ozone in the atmosphere and break or deplete it.

12. Cholera: An acute endemic disease caused by vibrio comma, vibrio cholerae and El-Tor cholerae. It is characterized by bilious vomiting and severe diarrhoea and spread by contaminated water, food, overcrowding & insanitary conditions.

13. Climate Change: Change in average weather which is attributed directly or indirectly to human activity that alters the composition of global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

14. Corticosteriods: A group of drugs that act in a similar way to naturally produced corticosteriods hormoues (synthesized by the adrenal cortex).

15. Crepitations: Soft cracking sound in the chest heard through a stethoscope, resulting from inflamation due to pneumonia or other diseases of the chest.

16. Denque: Otherwise known as dandy-fever or breakbone fever, it is a tropical endiemic fever, but seldom fatal.

17. Droplet: A particle of liquid substance of very small mass (up to 20- diameter), capable of remaining in suspension in a gas.

18. Drought: Non-availability of adequate amount of water for man, animals & plants.

19. Earth's radiation balance: A natural process in which the input of solar-energy equals the output of both short-wave and long-wave radiation.

20. El-Nino: A warm ocean surface current affecting the Peruvian coast every ten or so years.

21. Encephalitis: Popularly called sleeping sickness or sleepy-sickness, is an acute disease marked by profound physical and mental lethargy.

22. Failure: The word is used in TB control to identify TB patients who are found to be smear positive at end of five month after start of TB treatment.

23. Floods: A relatively high water level or discharge above an arbitrarily selected flood level or flood discharge.

24. Haemoptysis: A health condition in which a patient is found to be spitting or coughing up blood from the lungs, especially in advanced TB.

25. Hydrobromofluorocarbon: Chemical compound containing hydrogen, bromine, fluorine and carbon.

26. Hydrochlorofluorocarbon: Similar to '25' above but bromine is replaced by chlorine.

27. Human Immunodeficiency virus: A virus acquired mainly through unprotected sexual intercourse, blood transfusion etc, and which breaks down the human body's natural immune system.

28. Ice Ages: A period dating back to about 2.5 million to 10,000 years from now.

29. Immunosuppressant: Any drug that inhibits the body's immune response to anything that is new or foreign.

30. Interglacial: Period or occurring between two glacial actions.

31. Malaise: Health condition of feeling of debility or of impending sickness.

32. Malaria: A tropical disease caused by plasmodium and carried by infected mosquitoes of the genus anopheles.

33. Mantoux test: A test conducted to ascertain TB infection in individuals.

34. Meningitis: Inflammation of the membranes covering the brain or of the spinal cord.

35. Meteorology: A branch of geography that studies weather and climate.

36. Methane: A colourless, odourless, inflammable gas and simplest form of hydrocarbons, produced by decomposition of vegetable matter in wet conditions.

37. Miliary: A form of TB which spread through large parts of the body in large numbers and appears like millet seeds on X-ray film.

38. Mycobacterium: A genus of bacteria that causes TB and Leprosy (Tubercle and leprae respectively).

39. Nitrons Oxide: On oxide of nitrogen which contributes to the effect of greenhouse.

40. Ozone: An allotrophic form of oxygen found in the atmosphere.

41. Paleoclimatology: The study of climate at any stage in the geological development of the earth.

42. Pleura: A delicate serous membrane that covers the lungs and lines the cavity of the chest.

43. Pneumonia: Inflammation of one or both lungs from infection with disease.

44. Relapse: Reappearance of and confirmation of TB by microscopy on TB patients who were previously treated for active TB and declared "Cured" after complete course of TB treatment.

45. Salmonellosis: Food poisoning caused by infestation of food contaminated by salmonella bacteria.

46. Smear Positive: Visibility or appearance of acid-fast bacilli on Ziel-Nelson stain.

47. Stratospheric: Refering or relating to the stratosphere (the space between about 10-80 km above sea level).

48. Sustainable development: A development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

49. Tuberculosis: A disease caused by mycobacterium tubercle and affects mainly the lungs.

50. Ultraviolet Rays: Radiations of wavelengths less than those of visible light.

51. Vulnerability: The extent to which climate change may damage or harm a system.

52. Yellow Fever: An acute disease mainly occurring in tropical America & W/Africa, caused by infection with a virus transmitted to humans by the bite of a mosquito and characterized by high fever, acute nephritis, jaundice and haemorrhages.