Behavioural pattern of Tuberculosis in Sudan from 1995 through 2009

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ABSTRACT

Tuberculosis (TB) is a major cause of morbidity and mortality in Sudan and has place and time implications. The objective of this paper is to identify the time pattern of tuberculosis at national, regional and seasonal scales in order to assist with its reduction among the majority of poor Sudanese. The design of the paper focuses on tuberculosis time trends from 1995 through 2009, based on Sudan National Tuberculosis Control Program data. Results depict fluctuation of TB, though national data indicates annual increase of 6.6% of all cases of the disease. Tuberculosis was steadily rising prior to 2000 and slightly dropped by 2008. Prevalence rates are decreasing versus population increasing from the year 1999 onward. Wide dispersion of tuberculosis cases is noticed during winter while it was less during Summer, Spring And Autumn. Differences in tuberculosis seasonal distribution are smaller between males and females during winter and spring, but increased slightly towards Summer and Autumn. Tuberculosis is more prevalent among young and old males rather than females. In the sex - age group, 0 – 14, females exceeded male by 8.29%. In the sex - age group of 15-24 male exceeded female by 17.35%. Thereafter, males recorded higher. During early childhood; females are more vulnerable to infection than males. Regional ranking of tuberculosis puts central region first then eastern, southern, western and northern regions respectively. The findings illustrate disordered and clustered pattern of dispersion of tuberculosis cases and establishes a confident relationship between population and tuberculosis. In conclusion, the author proposes COPOVINNLIT program for reduction of TB in Sudan.

Keywords: Tuberculosis**,** Diseases, Sudan; Time ; Age–sex structure; Poverty.

INTRODUCTION

Tuberculosis is an airborne debilitating chronic infection caused by Mycobacterium tuberculosis complex which is a small aerobic non-motile bacillus. It spreads through the air when people who have the disease cough, sneeze, spit or shout which is common in some cultures. The risk of infection is highest in cramped homes with little ventilation Most infections in humans result in an asymptomatic, latent infection, and about one in ten latent infections eventually progresses to active disease, which, if left untreated, kills more than 50% of its victims (Konstantinos, 2010). The World Health Organization estimates of the global burden of disease caused by TB in 2009 as 9.4 million incident cases (range, 8.9 million–9.9 million), 14 million prevalent cases (range, 12 million–16 million), 1.3 million deaths among HIV-negative people (range, 1.2 million–1.5 million) and 0.38 million deaths among HIV-positive people (range, 0.32 million–0.45 million). Most cases

were in the South-East Asia, African and Western Pacific regions (35%, 30% and 20%, respectively) (WHO, 2010a). An estimated 11– 13% of incident cases were HIV-positive; the African Region accounted for approximately 80% of these cases (WHO, 2010a). Moreover, TB annual impact in the world is that in each year a total of 9 million new cases are added with more than 1 million cases among people living with HIV and half a million cases of MDR-TB and nearly 2 million deaths (WHO.2010). Also, it is indicated by (Médecins Sans Frontières Australia, 2008) that TB kills around 1.6 million people every year worldwide and another nine million are suffering from the disease and imposes a global burden of an estimated 8 million new cases. Tuberculosis kills approximately 1 million women per year and it is estimated that almost 1 billion women and girls are infected with TB worldwide (Thorson, et al., 2001). During adolescence rates begin to diverge and there is a much higher incidence in men than in women during adulthood. The relative risks reduce again in the older age groups.

In Sub-Saharan Africa including Sudan, approximately 300 per 100,000 are sickened annually by this disease. Around 110,000 people die of Tuberculosis every year and kills more people in the eastern Mediterranean region than other major communicable diseases (4). Sudan holds 8 - 11% of the TB burden in the eastern Mediterranean region (Elyas, 2007)**.** In 2007, the incidence of all forms of TB at an estimated 243 cases per 100,000 population in Sudan (SNTP,2009). The estimated incidence of new smear-positive cases of 90 per 100,000 population gives a total of 32,614 estimated new smear positive cases for a 33.6 million population of whole Sudan (SNTP,2009).

The main objective of this paper is to identify time pattern of tuberculosis in Sudan, nationally, regionally and seasonally in order to assist with its reduction among the majority of poor Sudanese. The author proposes COPOVINNLIT after "**co**mbating **pov**erty and **inn**ovating **lit**eracy" program for reduction of TB in Sudan (Fig.5). The COPOVINNLIT is considered integrative as each component is integral to other components in the program. The COPOVINNLIT depends on the ground that, in order to reduce TB in Sudan we have first to combat poverty and innovate literacy since TB is highly correlated with poverty and illiteracy. The COPOVINNLIT has social, economical and political strategies. These strategies have national, regional and local levels and have long, medium and short time periods.

MATERIALS AND METHODS

(a) Data sources and statistical analysis

Data is provided by the Sudan National Tuberculosis Program (SNTP) which usually includes new smear positive, relapses, smear negative and extra – pulmonary cases of tuberculosis. New tuberculosis cases by sex and age structure and seasonal distribution of tuberculosis cases by quarter a year are confined to the years 2003-2007 due to lack of data. Data for southern Sudan covers up to 2007; Data for Sudan population is obtained from publications of United Nations, World Bank, and Central Bureau of Statistics of Sudan. Regional population data is obtained from Annual health reports of Ministry of Federal Health of Sudan.

Time trends for tuberculosis are measured numerically, proportionally, and directionally to depict yearly and seasonal changes by prevalence rates which are calculated by dividing the number of tuberculosis cases by total population and multiplying by 1,000.

Proportional change of tuberculosis is shown via index numbers for Sudan and by regions; actual figures were converted to percentages by taking the year 2000 as the base year to facilitate comparison across all figures. Seasonal distribution of tuberculosis included Winter (January – February and March); Spring (April, May and June); Summer (July, August and September); Autumn (October, November and December).The standard deviation is calculated for national and regional distribution of tuberculosis by seasons. General trend line is also calculated for the periods 1995-2001 and 2002-2009 by taking the average for each period against the mid - year 1997 and 2004 respectively.

Regional agglomeration was carried out by including many administrative states in each of five geographic regions: the central, northern, eastern, western and southern regions. This regional division follows the general mental map held by Sudanese as to the spatial division of their country. Pyramid of new tuberculosis cases in Sudan, 2003-2007 was established by putting males versus females into the vertical axis corresponding to percentages in the horizontal axis. Spearman's rank correlation between population and tuberculosis 3 years running prevalence rates by regions was calculated as $r = 1 - 6 \sum d^2 / n (n^2 - 1)$,where $\sum d^2$ is the sum of squares of differences between population and prevalence rate for each region and *n* is the number of regions.

The result of this correlation is tested under 0.1 confidence level to see that the null hypotheses (that there are no statistically significant relationships in three-year tuberculosis prevalence rates between population and tuberculosis 3 years running prevalence rates by regions of Sudan) is rejected if the calculated *r* - value is greater than the critical value under the chosen confidence level. Chi- square is used to see type of regional dispersion of new infected tuberculosis cases either they are uniform, random or clustered by using the equation: $x^2 = \sum(A - B)^2/ B$, where A is the observed distribution, B is the expected distribution. This value compared three-year prevalence rates of tuberculosis across major regions of Sudan to establish significant differences at the 0.1 level.

RESULTS AND DISCUSSION

(a) Time behaviour by national level

Sudan is located in east Africa and surrounded by nine countries (Fig.1). Tuberculosis cases increased from 14,327 in 1995 to 22,097 in 2009 giving annual addition by 6.6% (table 1). It rapidly increased between 1995 and 1999, slightly fluctuated between 2000 and 2007 and decreased by 2008. Proportional change of tuberculosis (Fig.2) depict that prior to 2000, tuberculosis continuously raised and was stable and continuously dropping up to 2008. Three years running means (Fig.3) depict steady increase from 1995 through 2000, then slightly decreased in 2001 to restart increasing up to 2006, thereafter tuberculosis declined. Tuberculosis prevalence rates (Table1) increased between 1995 and 1999 and then steady decreased thereafter. Yearly differences in prevalence rates are quite small.

Although Sudan population is increasing, tuberculosis prevalence rates are decreasing since 1999. The highest mean value of tuberculosis by seasons goes to Winter and the lowest to Summer with standard deviation values of 0.77; 57.9; 224.4 and 41.6 by seasons respectively. The lowest value of the standard deviation is close to the mean value of Summer, followed by Spring, Autumn and Winter. Sex - age groups show females age group of 0 – 14 as exceeding males by 8.29%. In the second group of 15-24, males exceeded

females by 17.35% (Fig.4). From thereafter males recorded higher. The two age groups, 25-34 and 65+ of males, recorded the highest among all other sex-age groups contrasting similar females age groups. Tuberculosis prevails more among adult and old males and also more evident among the younger females. The females' age groups of 35-44 and 45-54 are close to the second age group of females. Seasonal distribution of tuberculosis distinguished the highest incidence during Spring while the lowest during Autumn. Differences are very small between males and females during Winter and Spring and slightly higher during Summer and Autumn. Seasonal infection of tuberculosis by sex is similar and differences are almost constant.

Table (1): Population, T.B. cases, prevalence rate and the three years running prevalence rates, 1995-2009 in Sudan

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Population (million)	27.95	28.60	29.20	29.80	30.40	31.10	31.90	32.70	33.60	34.47	35.30	36.22	37.16	38.13	39.12
T.B. cases (000)	14327	20293	20909	22833	26963	25108	24013	24595	25126	24671	25565	25328	24357	21422	22097
Prevalence rate	0.51	0.70	0.71	0.77	0.88	0.81	0.75	0.75	0.75	0.71	0.71	0.70	0.66	0.56	0.56
3 yrs r. P. Mean	-	0.64	0.72	0.78	0.82	0.81	0.77	0.75	0.73	0.72	0.70	0.69	0.64	0.59	-

Source: Population United Nations Population Division of Department of Economic and Social Affairs, World Bank, and Central Bureau of Statistics, Sudan.

Fig. 1: Location and states of Sudan

Fig.2: Proportional change of T.B in Sudan, 1995 – 2009

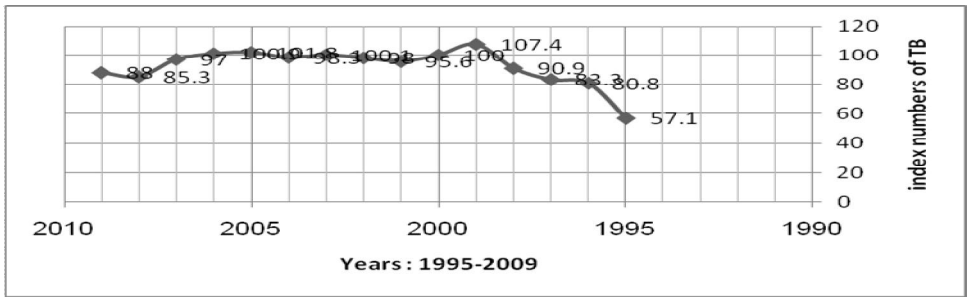


Fig.3: Three years running means of Tuberculosis in Sudan, 1995 – 2009

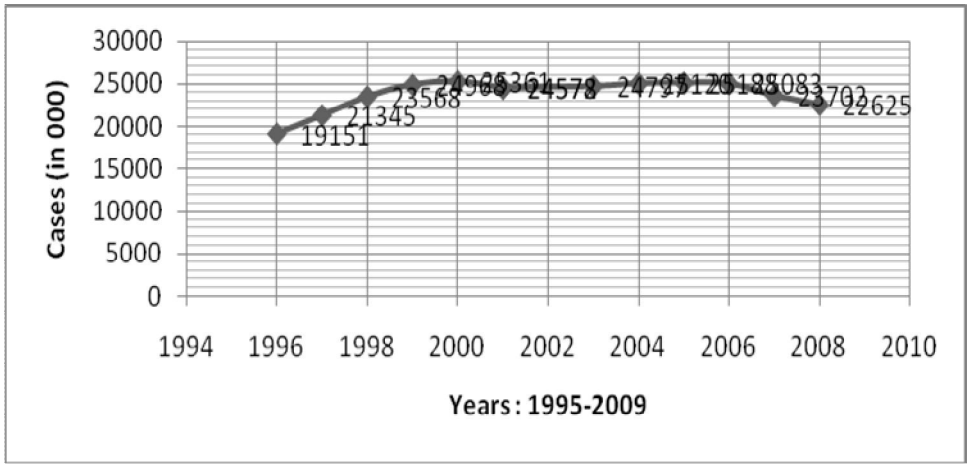
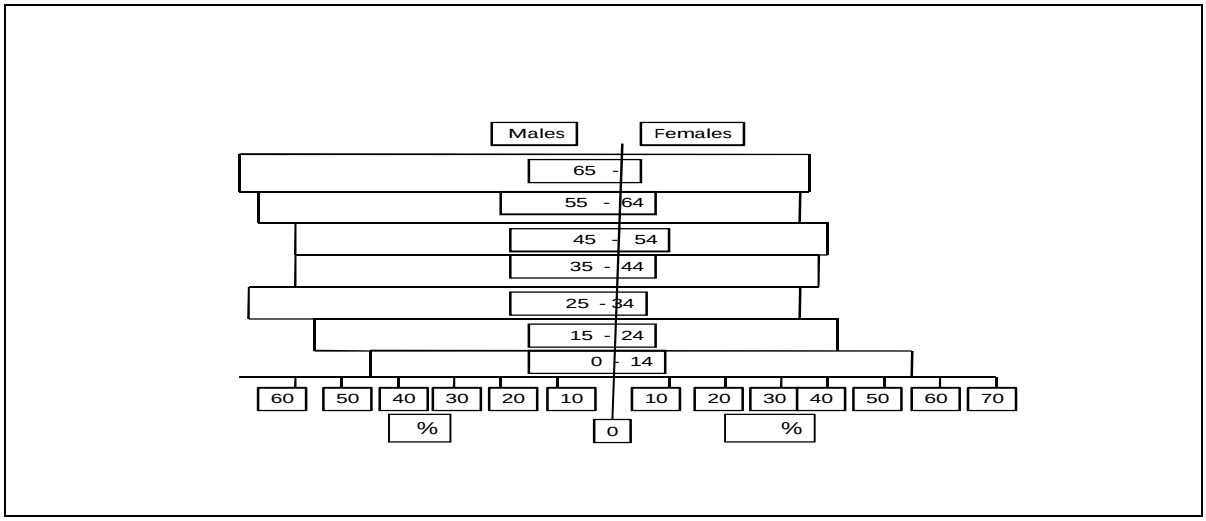


Fig. 4: Pyramid of new tuberculosis cases in Sudan, 2003-2007



(b) Time behaviour by regions

Regional agglomeration distinguished northern, central, eastern, western and southern regions. Regional ranking by mean of tuberculosis puts central region first then eastern, southern, western and northern regions. This ranking is also kept by central, northern and southern regions for the mean population while western and eastern regions exchanged their ranking position. The standard deviation shows great dispersion of tuberculosis in the central region ($\bar{x}$ = 13,063 and SD = 1412.7. The northern region has closer values ($\bar{x}$ = 963.73 and SD= 282.9), the eastern region has very sharp difference ($\bar{x}$ = 4,054 SD =

689.69), the western region also has wide dispersion ($\bar{x}$ = 2, 472 and SD = 593.01) and southern regions similarly depicted wide dispersion ($\bar{x}$ = 2,542 and SD =927.1). The calculated qui square value of 30,201 is far bigger than zero value confirming for disordered and clustered regional dispersion of new tuberculosis cases to agree with the standard deviation values. This is because of the observed excess clustering of new cases tuberculosis cases in central region of Sudan.

Regional proportional change of tuberculosis (table 2) distinguished central region during the pre base - year period by steady increase with very small differences and in the post base - year period tuberculosis fluctuated with big differences between the years considered. In northern region, tuberculosis dropped during the pre base - year period and fluctuated in the post base – year period. In eastern region, tuberculosis fluctuated for both pre and post base year periods. In the western region, tuberculosis raised sharply in the second year of the pre base - year period, declined sharply and then remarkably increased showing very fluctuating behavioural pattern. In the post base - year period, western Sudan depicted fluctuating pattern. For the southern region, tuberculosis steadily increased and fluctuated in the pre base – year period and similarly fluctuated during the post base – year period.

General and three years running prevalence rates of tuberculosis (table 3) are decreasing in central, northern and eastern regions, regardless of very minor fluctuations. Western region has similar rates in the first three and second three consecutive years then raised spontaneously in 2006 and then dropped down closely to the previous rates. Southern region rates have fluctuated by general prevalence rates while the three years running prevalence rates are almost similar. The calculated value of Spearman's rank correlation between population and tuberculosis regional prevalence rates is 0.3, tested under 0.1 confidence level to give the critical value of 0.9. This last value is bigger than the calculated value (0.3) to enable the rejection of null hypothesis (H_o) that there is no relationship between regional population and regional tuberculosis prevalence rates and to accept by 99% confidence level that there is relationship between both. In the northern region more infections by tuberculosis occur during Winter (28.2%) similar to southern region (31.2%) but contrasting central (26.7%) and eastern regions which are tending towards Spring (28.4). The lowest records are witnessed during Autumn for all regions as 23.9% for central; 21.1% for northern; 21.9% for eastern, and 21.8% for southern except western Sudan (29.9%). Differences tuberculosis infection during the Spring and Summer are very close in northern (25.9% and 24.4%), western (25.8% and 24.8%) and southern (23.5% and 23.5%) regions while more differences are there in the central (26.7% and 24.9%) and eastern (28.4 and 24.3%) regions.

Table (2) Proportional change of T.B by regions of Sudan, 1995 – 2009

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Central	49.3	69.8	78.6	89.9	104.5	100	94.6	101.9	96.9	98.0	98.3	99.7	99.1	86.6	92.6
Northern	186.4	166.8	66.9	89.1	84.1	100	83.1	67.8	84.8	82.0	77.1	60.0	62.0	51.1	52.4
Eastern	29.5	86.9	88.9	103.1	116.5	100	89.8	98.6	102.8	99.3	88.3	86.3	90.5	92.7	92.6
Western	84.8	158.7	51.8	70.9	106.0	100	103.9	118.4	148.8	152.6	171.5	161.5	203.2	241.9	229.8
Southern	37.6	51.3	117.3	90.1	114.1	100	108.2	78.5	89.6	74.7	106.5	109.7	52.6	-	-

Table (3): Population, T.B. cases, prevalence rate and the three years running prevalence rates, by regions of Sudan,1995-2009

Years	Population					T.B. cases					Prevalence rate					3 years running prevalence rate				
	C	N	E	W	S	C	N	E	W	S	C	N	E	W	S	C	N	E	W	S
2000	11399	1482	3655	9510	5035	14407	1095	4452	1763	3374	1.3	0.7	1.2	0.2	0.8	-	-	-	-	-
2001	11785	1588	3756	11753	5191	13634	910	3998	1833	3652	1.2	0.6	1.1	0.2	0.7	1.2	0.6	1.1	0.2	0.6
2002	12143	1593	3840	10002	5202	14695	742	4398	2087	2649	1.2	0.5	1.1	0.2	0.5	1.2	0.6	1.1	0.2	0.6
2003	12603	1568	3937	10255	5285	13959	929	4577	2624	3022	1.1	0.6	1.2	0.3	0.6	1.1	0.6	1.1	0.3	0.5
2004	13003	1596	4033	10515	5366	14124	898	4422	2691	2522	1.1	0.6	1.1	0.3	0.5	1.1	0.6	1.1	0.3	0.6
2005	13414	1624	4131	10779	5448	14160	844	3929	3024	3594	1.1	0.5	1.0	0.3	0.7	1.1	0.5	1.0	0.9	0.6
2006	13833	1652	4231	12271	5530	14365	657	3841	2847	3701	1.1	0.4	0.9	2.2	0.7	1.1	0.4	0.9	0.9	0.6
2007	14282	1680	4335	12546	5616	14272	679	4031	3583	1776	0.9	0.4	0.9	0.3	0.3	1.0	0.4	0.9	0.9	-
2008	12697	1819	4534	12864	8260	12476	559	4129	4264	NA	0.9	0.3	0.9	0.4	NA	1.0	0.4	0.9	0.9	-
2009	13112	1932	4742	13182	1040	13348	574	4123	4052	NA	1.0	0.3	0.9	0.3	NA	-	-	-	-	-
Mean	12,827	1653	4119	11367	5197	13944	789	4190	2877	3036	1.1	0.5	1.0	0.4	0.6	-	-	-	-	-
Rank	1	5	4	2	3	1	5	2	4	3	1	4	2	5	3	-	-	-	-	

Source: *Population United Nations Population Division of Department of Economic and Social Affairs, World Bank, and Central Bureau*

Tuberculosis is a real health problem in Sudan although our analysis showed its decreasing versus population increasing in the country. Estimated TB incidence per 100 000 population by country by WHO in 2009, put Sudan within the group range of 100-299, which includes countries like Chad, Mali, Mozambique, Tanzania, Madagascar, India, Pakistan, Afghanistan, former Soviet Union Republics including Russia, Malaysia and Ecuador. At the same time Sudan has less TB incidence than all African countries lying south of the equator and some others in Asia such as Myanmar and north Korea which lay within the range ≥ 300 incidence rate **(** WHO a,2010**).** This puts Sudan in a position similar to many other countries world widely concerning this major health problem. In Brazil there are about 57 million Brazilians are tubercular, placing Brazil among the 22 countries with 80 percent of cases worldwide (news.xinhuanet.com.2010). Generally, Brazil, ranks 14th on the list of 22 high-burden TB countries in the world and accounts for 31 percent of all TB cases in the World Health Organization's Latin American Region **(**usaid.2011). Similarly, Indonesia is more worser than Brazil which has the third highest rate of tuberculosis in the world and more than 90,000 people die from the disease every year (News.xinhuanet.com,2011).

In the western Pacific region including countries like Cambodia, China, the Philippines and Vietnam, tuberculosis remains a major public health problem where more than 20% of the global burden of TB is found in that Region. In 2007, there were an estimated 1.9 million incident cases (109 per 100,000 population). Four countries (Cambodia, China, the Philippines and Vietnam) account for 93% of the total estimated incident cases in the Region **(**Van Maaren, 2010). Sudan is also similar to some Arab countries facing the same problem. A Sana'a University study has shown that there is a high

rate of extra pulmonary tuberculosis cases among Yemeni tuberculosis patients, when compared to other Arab states (Thuria,2007).

Although Egypt is not on the World Health Organization list of 22 countries with a high tuberculosis burden, it is considered one of the high-burden countries in WHO's Eastern Mediterranean region **(**usaid.2011). The World Health Organization warned of the increasing rates of tuberculosis infection in Egypt in 2008 (flutrackers.com/forum,2011)**.** Even more, some European countries are facing tuberculosis problem similar to Sudan. In England and Wales in the period 1988 to 1992, the notified cases of TB increase by 12 per cent (Barry,1999). Tuberculosis rates in some parts of the UK are at 'Third World' levels (News.bbc, 2002).

Russia ranks 11th on the list of 22 high-burden tuberculosis (TB) countries in the world **(**USAid.2011). However, Sudan contrasts Cuba which has an incidence rate of seven tuberculosis (TB) cases per 100,000 inhabitants, one of the lowest in the world. "This achievement is the result of the systematic monitoring and treatment programs developed by the health authorities after the triumph of the Cuban Revolution in 1959," (News.xinhuanet.com, 2011). Nonetheless, Sudan is better than South Africa which ranked fifth on the list of 22 high-burden tuberculosis (TB) countries in the world **(**usaid.2011).

The general behavioural pattern of TB is fluctuating in Sudan is indicating to a peak during Spring, males are more vulnerable to infection by tuberculosis than females and Central region ranked first among other regions of Sudan and has a peak of tuberculosis during Winter similar to the southern region. There is Spring peak in central and eastern regions while Autumn peak is noticed in western region of Sudan. These findings illustrate tuberculosis temporal and geographic variations in Sudan as well as socio-economically, environmentally, and geographically related situations. Poverty in Sudan is evident where 77.5% of population were on or below the poverty line (Ministry of Labor (MoL/ ILO).1997) and 75% of them were classified as poor (UNDP,2005). Nutritional status of the majority of Sudanese is low particularly among younger children. Studying children less than ten years in western Kordofan revealed that they are stunting, underweight and malnourished (Alredaisy,et al., 2011).This agrees with higher prevalence rates of tuberculosis among 0-14 years old children in Sudan and similar to notifications of tuberculosis increase by 35% in the poorest 10th of the population in England and Wales (Law, et al., 1995).

Tuberculosis has grown steadily and becoming worse in Sudan due to migration for environmental, economical and political factors such as civil war in southern and western Sudan (SNTP,2009). Displaced people live in overcrowded conditions suitable for spread of tuberculosis as It has been found that 56% of African refugee children may be infected with intestinal parasites and there is potential that the "riskier" migrants may spread infectious disease to individuals(www.faqs.or., 2010). This points to the role of high population density in the spread of TB in Beijing (Amesh, 2008). Also, civil war in Sudan led to rife poverty, rampant malnutrition and lack of hygiene among displaced and migrants similar to Tiruvallur in Tamil Nadu (India), where irregular and incomplete treatment on account of migration is likely to increase the burden of TB (Jaggarajamma, et al., 2007). This agrees with the role of immigration in Norway where the proportion of patients born outside Norway is increasing due to immigration from countries with high incidence of tuberculosis being infected in as children or adolescents infected before arrival (Norwegian Institute of Public Health, 2011).

Seasonal distribution of tuberculosis by regions of Sudan distinguished Winter peak In the northern and southern but, contrasting central and eastern regions which are tending towards Spring. The lowest records of tuberculosis are witnessed during Autumn in all regions, except western Sudan. Differences tuberculosis infection during the Spring and Summer are very close in northern, western and southern regions while more differences are there in the central and eastern regions.

In the northern and southern regions Winter peak of tuberculosis contrast Summer peak in Hong Kong (Chi Chiu Leung; et al., 2005) while central and eastern region Spring peak conform with northern India (Thorpe, et al., 2004). Seasonal regional variations in Sudan go with monthly trends in Moldova, Mongolia, Uganda and Zimbabwe which were most marked in Mongolia with ambient temperature (Biggie, et al., 2009). Tuberculosis is more found among males rather than females which commensurate with Moldova, Mongolia, Uganda and Zimbabwe (Biggie, et al., 2009) and also with general data for Africa (World Health Organization (2006).

This study confirmed that females during early childhood are more vulnerable to infection by tuberculosis than males. This contrasts most countries where there is no significant difference in TB between males and females during early childhood and pre-adolescence (Ana Bierrenbach, 2010). Female TB patients tended to be younger than male patients. Patients from the high incidence, indigenous population in Delta Amacuro state in Venezuela were younger and had a nearly equal male : female distribution (Edgar, et al., 2009). Among tribal population of Car Nicobar in India, it was found that 95.8% of the children enumerated were tuberculin tested and read while 16.4% of children without bacille Calmette–Guérin scars were infected with TB. The prevalence of TB infection and smear-positive cases of TB increased significantly between 1986 and 2002 (Murhekar, et al., 2004).

Regional differences into tuberculosis have ranked central region first because it includes agricultural investments and the Capital city of Sudan which accepts large numbers of internal migration when, for example, the role of migration in the spread of malaria in Thailand is identified (Singhanetra - Renarg,1993). National and regional aspects of tuberculosis are associated with illiteracy, inadequate water supply, and low governmental expenditure in the health sector. As of 2007, the adult literacy rate (for the population aged 15+ years) was 49.9 % (50.9 % for men and 49.9 % for women). In 2006, 59.2 % of the population had access to safe drinking water. In 2002, adequate facilities for the disposal of excreta were available for only 31.4 % of Sudan's population, and as of 1999, health care was available for only 70 %. Population growth was not accompanied by proportional development in the health sector. In 2000, the health sector received 2.08 % of the total budget; in 2004, 1.68 %; and in 2005, 2.20 %, while actual expenditure on the health sector in 2007 was only 0.31 % of the total budget. The national average is 15.4 doctors per 100 000 population (Ministry of Health, Sudan. 2008).

CONCLUSION AND RECOMMENDATIONS

The results reported here indicated significant for TB at both national and regional levels in Sudan as a serious health problem. However, World Health Organization (WHO, 2010 b) states that "without dramatic increases in funding and political commitment between 2010 and 2015, it is estimated that over 50 million people will develop active TB; over 10 million lives will be lost to this preventable, curable disease; 4 million of them will be women and children; millions of children will be orphaned needlessly and over 2 million

cases of MDR-TB will emerge for want of proper care". This is an important message for Sudan to work hard to reduce TB in the country. The author's proposed COPOVINNLIT program for reduction of TB in Sudan (Fig.5) can work with that.

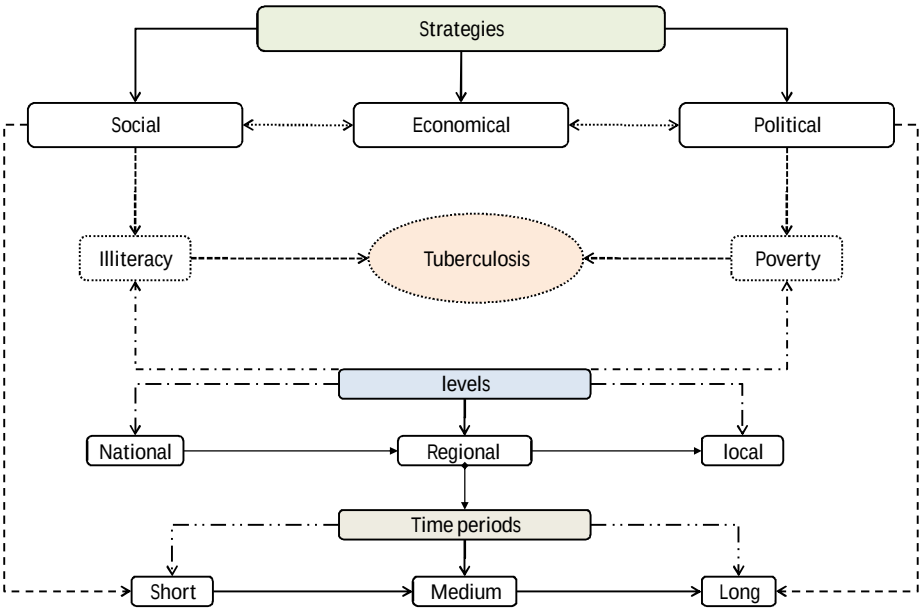


Fig.5: COPOVINNLIT program for reduction of TB in Sudan

The three integrated strategies outlined in the COPOVINNLIT program (Fig.5) target reduction of poverty and literacy innovation at national, regional and local levels. Targeting poor population in rural and urban areas is essential since they generally live in overcrowded houses and have low income. This is through sustainable socioeconomic and political developments which have to imply some TB program specific issues. Sustainable socioeconomic development should guarantee income generation to add to a community living standard, not only by national, regional and local economic projects, but also through micro finance for families in rural and urban areas. This will, of course, increase per capita and households' incomes which will improve nutritional, housing and general health conditions all will have good implications on the reduction of TB in Sudan. They have also to imply relevant specific TB issues related to community health awareness such early intervention programs of vaccination and primary information about TB to be diffused by posters and vocal media. Strategies for diffusion and innovation of TB information have to start from down to top by implying local concerned bodies first, who have ability to communicate with local people in simple language. Activation of volunteers, schools' children during school vacations and local TV and Radio stations are imperative to innovate health education on TB with focus on a season with higher incidence of TB considering geographic and age – sex differences.

Moreover, political strategy has to work towards political stability, alleviation of wealth disparities in the country and enhance equitable distribution of GDP to reduce migration as a real factor into transmission cycle of TB in Sudan.

Time schedule for each strategy can focus on applicable components of each strategy considering financial obstacles for implementation. They have to give priority to grass root

communities. Up to date information should flow throughout authorized networks concerned with each strategy in order to cope with recurring situations of TB in Sudan. During each time period, specific targets of each strategy which are designed for a particular level have to be implemented.

Future work should concentrate on identifying risk factors contributing to seasonal/regional differences as well as better understanding how intervention programs would improve the rates of early detection and TB survival for all Sudanese. The application of the COPOVINNLIT model in Sudan can work to reduce TB in order to decide on appropriate methods through activation of the strategies at the various levels and through the time periods outlined by the model. However, the COOPVINNLIT model can also be applied for any other similar infectious disease in similar places in Africa, Asia, and Latin America.

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