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Medicine, Science and Society – The Global Health Imperative

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Professor Abdulrazaq Garba Habib

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SUMMARY OF PRESENTER'S BIODATA

Professor Habib is an infectious and tropical diseases physician, public health implementer, epidemiologist, educator and a professor since 2009. He trained and worked at institutions and University Hospitals in Zaria, Abuja and Kano, Nigeria; King Khalid University Hospital, Riyadh, Saudi-Arabia; University of Newcastle Medical School, Newcastle General Hospital, England-UK and National University Hospital, Singapore. He has interests in global health (including community acquired infections, antimicrobial resistance, emerging infections [Ebola, SARS], Human Immunodeficiency Virus (HIV) infections, immunology, clinical epidemiology, tropical diseases, snakebite envenoming and health economics). Currently, he teaches modules on immune response to infections; HIV/AIDS; HIV-Tuberculosis, snakebite, sepsis, parasitic infections and typhoid fever at undergraduate level.

He trained and supervised 1 Masters of Science (Immunology) at ABU, external examiner to 3 Masters of Sciences in Microbiology and Immunology (ABU), co-supervised 3 PhD students to completion (Faculty of Veterinary Medicine, ABU), external examiner 1 PhD (Microbiology, University of Ilorin) and supervised 15 medical doctors to full completion of medical fellowship. He is a member of research workgroups including Infectious Diseases Work Group; Health Economics and Outcomes Research; Clinical Epidemiology Workgroup; and the Venom Antivenom Research Group (VASP) at BUK. Earlier in April 2017, Professor Habib and the VASP-BUK were successful in the UK's National Institute of Health Research (NIHR) Global Health Research award for the sum of 2 million pounds to the new consortium 'NIHR Group on African Snakebite Research', comprising Professor Habib and VASP-BUK Nigeria, two Units in Cameroon and Kenya with headquarters at Liverpool School of Tropical Medicine and Hygiene, UK.

He participated in the initial characterization of a new emerging infection Corona Virus – Severe Acute Respiratory Syndrome (CoV-SARS) in Singapore. He served as Director, Medical Services (2005-7) to Institute of Human Virology Nigeria (an affiliate of University of Maryland, USA) where they implemented care to over one third of HIV infected patients in Nigeria. He serves/served as member on several Boards and Committees including the National Drug Safety Advisory Committee, National Expert Committee on Adverse Events Following Immunizations, National Immunization Technical Advisory Group (Nigeria), the Epidemic Preparedness and Response Committee, National Committee on Multidrug

Resistant Tuberculosis, National Taskforce on the Control of Snakebite, Medical Advisor – Presidential Rapid Response Task Force on Avian Influenza, medical advisor to GSK Anti-infectives Advisory Board, medical advisor – Pfizer Vaccine Advisory Board, etc. He is member/fellow of the International Society of Toxinology, International AIDS Society, International Union Against Tuberculosis and Lung Diseases, International Society for Infectious Diseases and Royal Society for Tropical Medicine and Hygiene (inactive subscription). He was acting Chair of Friends for Global Health, affiliated to Vanderbilt Institute for Global Health, University of Vanderbilt, USA. Dr Habib is an International advisor to the Royal College of Physicians London (UK), member Board of Directors of the Melbourne-based Global Snakebite Initiative (GSI) and member West African Academic Alliance of the Accordia Foundation and West African Infectious Diseases Institute (WAIDI). He addressed a meeting of the 69th World Health Assembly, WHO, Geneva, Switzerland, 2016.

He is a recipient of many awards and prizes including co-recipient of the 3rd Prize of 'World Oxoid Infection Control Team of the Year Award, UK (2007) along with Mr Salisu Abubakar; Singapore Prime Minister's medal and certificate of appreciation/courage fund medal for valour and selfless dedication during the SARS epidemic in 2003; Winner Ayo-Iyun Prize for best result in West African College of Physicians examinations. According to *Research Gate* Abdulrazaq G Habib's research publications' statistics were: papers 114, citations 885, *h*-index 16 and RG score 35.29 – the best and highest at Bayero University Kano (https://www.researchgate.net/profile/Abdulrazaq_Habib/reputation; accessed 1 April 2017).

He has been invited regularly to speak at several meetings and leading institutions worldwide, the last being University of Southampton with over 60 oral presentations and has certificates from 57 courses attended at home and abroad. He has contributed five chapters in books and is an editor to a monograph on *Clinical Toxinology* (by Springer) and to three journals including a BMC international journal. He has written two Technical Reports on HIV/AIDS/ART and on TB-HIV for the Federal Ministry of Health, Nigeria and has participated in several surveys. He is a consultant physician in Infectious and Tropical Diseases at Aminu Kano Teaching Hospital, Kano, Nigeria and has supervised/mentored several trainees. He is also Chairman HIV Committee, BUK, the current president, Nigerian Infectious Diseases Society; former Head of the Infectious Diseases Sub-Specialty of the West African College of Physicians; examiner West African College of Physicians and Trustee of the Toxinology Society of Nigeria. He is the pioneer Provost of the College of

Health Sciences and formerly Head of Department of Medicine and Dean Faculty of Medicine, Bayero University, Kano, Nigeria. In his spare time, he is a member of Board of United Doctors, Darul-Hikma Educational Centre and the planned Darul-Hikma Medical & Healthcare Organization. Dr Habib is into educational philanthropy and was cited in the 'Marquis Who is Who in the World 2005-6' as a physician, educator and epidemiologist.

Born on 24th June 1964, Fulani by decent, Professor Habib hails from Galadanci, Kano. He attended at least four public primary schools including Gandun Sarki, Tarauni, Kurmawa and Dambatta Central. He then proceeded to Barewa College (Reg #4112) where he was House Prefect at Dan Hausa House in 1980-81. He finished with Division 1 Distinction, carting away prizes for best student in Mathematics and Physics. His father, late Alhaji Garba Habib (Reg #1163) and brother, Dr Zaharaddeen G. Habib (Reg #5197) also attended the same college. He studied and exited by examinations from Ahmadu Bello University, Zaria, Nigeria, University of London, UK, West African College of Physicians, Royal College of Physicians, UK, Academy of Medical Sciences Singapore (in Infectious Diseases) and the International Society of Travel Medicine. He is married with two wives and eight children. He is fluent in Hausa and English, proficient in Arabic, and has elementary French. He enjoys reading Islamic and English books, brisk walking, visiting museums, botanical and zoological gardens and travelling, and has visited nearly 30 countries throughout the world in all continents.

Medicine, Science and Society – The Global Health Imperative

In the Name of Allah The Beneficent The Merciful....

Knowledge (Wisdom) is the cherished property of a believer….valuing and taking it wherever he finds it .

– Prophet Muhammad (S.A.W)

….Enlighten us with what will benefit us…and benefit us with what you have taught us

– Prophet Muhammad (S.A.W)

The Vice-Chancellor,
Deputy Vice-Chancellor (Academic),
Deputy Vice-Chancellor (Administration),
Registrar,
Provost College of Health Sciences,
Deans and Directors,
Family, Friends, Colleagues, Students,
Distinguished Ladies and Gentlemen.

Preamble

I feel highly honoured to stand before you today to deliver this inaugural lecture from the Faculty of Clinical Sciences in the College of Health Sciences of our great University. I will be discussing on the growing influence of Global Health research and where appropriate, provide recommendations. The lecture will try to focus on how observations and research findings in basic, applied and clinical sciences are translated and implemented to provide healthcare to the individual and society. As the world has transformed into a global village and economy, so also are diseases, health, well-being and lifestyle issues interconnected, such that aspects from different parts of the world tend to affect even those who are

remote from the primary location of the event. This was recently exemplified by the Ebola, Zika outbreaks and many more.

Furthermore societal disparities and inequities means affected deprived populations are the most vulnerable to global health challenges. Such health problems often transcend and have no regard to national borders and they tend to have global political, security and economic impact. The foregoing taken together defines global health at least from an academic medical doctor's perspective. It may also entail health challenges related to human rights, social circumstances, displaced populations and refugees. As mentioned I will highlight these cognizant of the title: *Medicine, Science and Society: The Global Health Imperative*".

Vice-Chancellor Sir, I also beg to slightly deviate from tradition as I will be following my trodden paths, using milestones passed through and in particular, drawing on my humble experiences as a student, teacher, educationist, epidemiologist, physician, infectious disease practitioner, researcher and as an administrator/implementer to illustrate on the health issues that are all interwoven to highlight global health perspectives and prospects.

In an easy-to-follow narrative, I also hope to showcase the modest achievements resulting from collaborations, team work and mentoring I had privilege of imparting and receiving, and the benefaction received from so many for so many years.

Figure 1: *At a Focus Group Discussion with a Clan of Sullubuwa Semi-Nomadic Fulani at Danbare, Kano, 2011. They identified malaria,* ***'Laabi' or cattle paths*** *and zoonotic infections as their most important problems (presented in Lille, France 2011)*

1.0 Immunobiology

On graduating from medical school, there was such euphoria about immunology following the Nobel prizes awarded in particular for the discovery of monoclonal antibodies to Milstein and Kohler in the 1980s. This was first mentioned to us as 400L students by Professors Idris Mohammed (Dan Isan Gombe) and Geoffrey C. Onyemelukwe Nigeria's foremost clinical immunologists. Given the strong world class immunology and infectious

diseases research programme in Zaria then, the best and brightest among us all wanted to pursue a career in immunology. Some of my initial forays included an infatuation with a group of cells that protect against infectious agents called B cells and T-cells or lymphocytes. So one of my earliest review papers was to describe how, a then relatively new virus that affected T cells, Human T cell Leukaemia Virus (HTLV-1) could cause anomalies in matured T-cells resulting in a new type of cancer affecting the elderly over 60 years old with skin infiltration, high plasma calcium and high mortality (Habib, 1992a). This cancer known as Adult T-cell Leukaema (ATL) was first characterized in Japan and while in medical school, our professor of haematology, Alan Fleming, had confirmed presence of HTLV-1 in northern Nigeria (Fleming et al 1986).

I recall a symposium lecture on molecular and scientific basis of T-cell function in health and disease I gave in my last year in medical school chaired by our Hungarian super professor of microbiology, Lazlo Egler. To date, the subject never fails to fascinate me! Subsequently, two scientists characterized the T cell and one was given a Nobel prize – Rolf Zinkernagel – and Robert Gallo who discovered HTLV-1 and co-discovered HTLV-III or HIV-1, and their interactions with T cells, went unrewarded! Later in life, I met Robert Gallo while working as a director for the institute he found and where he serves as the overall director– Institute of Human Virology.

If ever there was an 'elixir for longevity' or a panacea for long life, it might entail stopping cells from dying. In a B-cell cancer called Follicular lymphoma, it was shown that a particular gene called **bcl-2** was abnormally translocated to be adjacent to the Ig gene. B-cells are known to make immunoglobulins (Ig) or antibodies and cells are programmed to die after living their course but the gene **bcl-2**inhibits programmed cell death (PCD). A patient we encountered with Follicular lymphoma, meaning his B-cells were not dying but living beyond their normal spans and growing in a cancerous manner, presented with unrestrained hyper production of antibodies presumably because of the **bcl-2/Ig** juxtaposition. The Ig heavy chain gene makes immunoglobulins and the juxtaposition facilitates its unregulated production. However, many of the auto-antibodies were able to lead to other diseases such as rheumatoid factor leading rheumatoid arthritis, Islet Cell Antibodies leading to Diabetes Mellitus (*Habib et al 1996*). This means longevity itself may be associated with other medical conditions – autoimmunity, cancer, diabetes, etc.

As a postgraduate student undergoing residency, my research dissertation entitled: *Assessment of Cell Mediated Immunity and Clinical Correlates in Pulmonary Tuberculosis* was supervised by Juliana Okpapi and Geoffrey Onyemelukwe, a very hardworking person who pushed us to our limits and we are now all the better! The study explored applicable aspects of immunology utilizing different tools and techniques including monoclonal antibodies which, as mentioned earlier, had a Nobel prize awarded following their discovery. I was able in a lab bench study to establish relationships between certain immunologic tests including T-suppressor cells (using anti-Leu 2a), T-helper cells (using anti Leu 3a), total T-cell (anti Leu 4) and B-cells counts (using anti Leu 12) and clinic-radiologic parameters.

In addition, immune function assays was done using leucocyte Migration Inhibition test (MI), in-vivo tests using tuberculin and candidin in HIV uninfected adult patients with and without BCG vaccination. These were correlated to sputum smear load of tubercle bacilli, radiologic features and effect of treatment. Meanwhile, at the time, global controversy had started gathering momentum that BCG vaccine, one of the oldest and most widely used vaccines in the developing world, was ineffective and does not protect especially among adults in the tropics. So, I had to investigate the effect of BCG and was able to show that BCG vaccination during childhood offers 'benefits' in adulthood, but immunological features including delayed type hypersensitivity (DTH) only manifests on re-exposure to *Mycobacterium tuberculosis*. The immune perturbations during an active disease appeared to abate/subside following tuberculosis treatment (Habib et al 1995).

In the course of undertaking an immunology module on therapeutic antibodies, I started studying antibodies/immunoglobulins used in treatment of poisoning, in particular, snakebite poisoning. Earlier as a medical student, I had already become aware of the extensive work of David Warrell in Nigeria (earlier on a senior lecturer in Zaria) and the developing world and had contacted him. This relationship has lasted from my years in medical school in 1987 to date.

Later, a Nigerian Minister for Health, Professor Olikoye Ransome-Kuti, recognized the menace of snakebite and started investing substantial funds to develop an antivenom to be used in Nigeria, using the same platform of ***Medicine, Science and Societal*** benefits to rural, vulnerable and mostly impoverished agricultural workers. Incidentally,the funding has been to the Ministry and partly supported academics in the UK including (emeritus

professors) David Warrell and David Theakston from Universities of Oxford and Liverpool. As a rookie Lecturer I/Consultant, I was one of the lead investigators in the clinical trial of these newly-manufactured polyclonal immunoglobulins and fragments used as antidote for snakebite poisoning. This was the first-time-in-humans, to use fragment of immunoglobulin tagged, papain digested and tagged Fab, against snakebite poisoning.

We hypothesized the smaller fragment will neutralize the venom throughout the relatively inaccessible parts of the body, and as they are of animal origin will likely cause less anaphylaxis or hypersensitivity given the Fc fragment had been removed (*Meyer et al, 1997*). Further, our group under David Theakston's leadership became the first in the world to use a then relatively new immunologic technique – Enzyme Linked Immuno-Sorbent Assay (ELISA) – to study the dynamics of poison (venom antigen) and antidote (antibody, immunoglobulin or immunoglobulin fragment) following bite [Figure 2] *(Meyer et al, 1997).*

To our disappointment, we found that although the product was very effective and efficacious in stopping snake "Gobe da Nisa's" or "Kububuwa's" poisoning related bleeding it was also excreted from the body very rapidly, presumably because of the small molecular weight which we had thought was a strength. It turned out to be its Achilles' Heels! These publications on immunology, sought to enlighten about the interactions of ***Medicine, Science and the Society*** issues of Global Health significance.

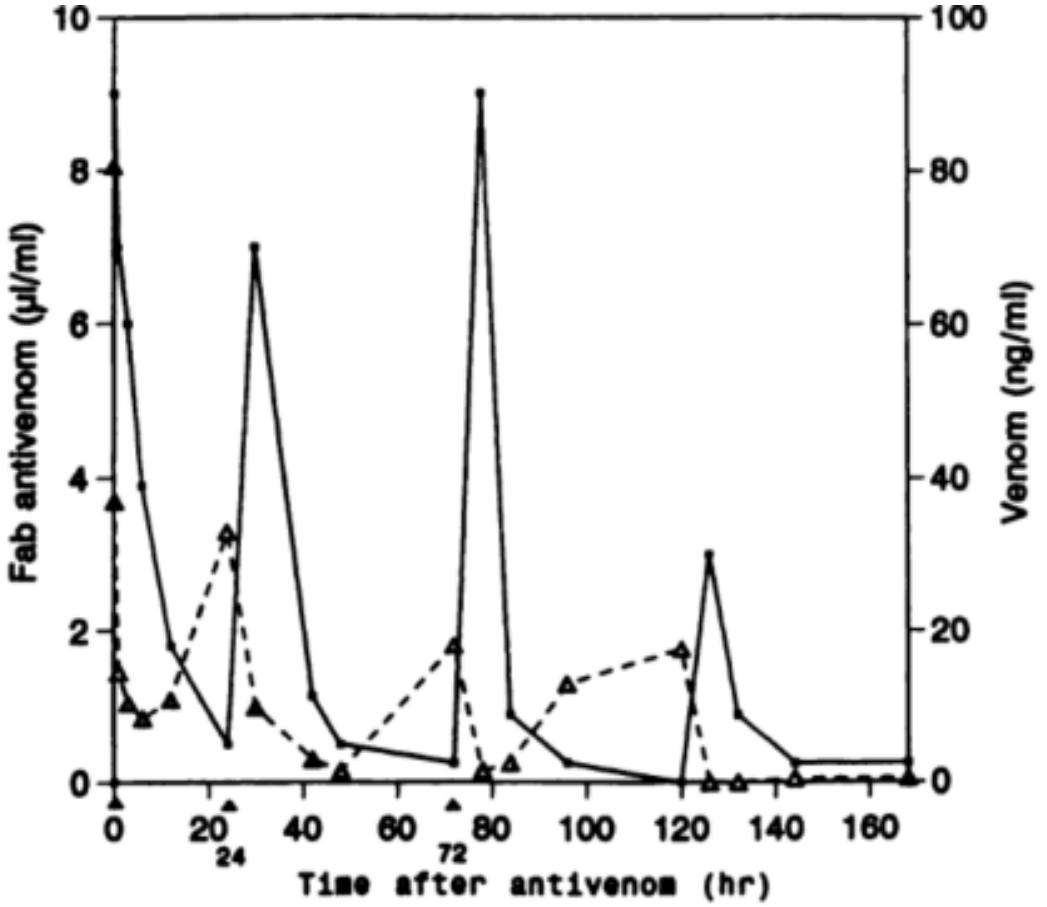

Figure 2: *Venom (dashed) and EchiTab Fab antivenom (solid line) levels in treated patients. Note recurrence of venom antigenaemia and incoagulable blood, indicating inadequate antivenom therapy. The dark triangles are points at which antivenom was administered. Each point is the mean level in the patient* (Meyer, Habib, Onayade, et al 1997)

2.0 Clinical Medicine (Non-Communicable Diseases [NCD])

I have been involved with characterizing some diseases that are iconic Clinical Medicine syndromes. A disease that was characterized early in northern Nigeria, Zaria in particular, is Post-Partum Cardiac Failure (PPCF). Earlier on, in my Zaria days, I wrote a review on PPCF highlighting, the then predominant theory of causation, trying to enlighten colleagues and the public. Eldryd Parry and his colleague, Neil McDavidson had uncovered/

discovered/rediscovered that women with advanced pregnancy, parturient women and postpartum women develop heart failure and they theorized – the Hausa/Fulani tradition of hot water bath, with 'darbejiya' or 'maina' leaves and ingesting 'Kunun Kanwa' gruel, which is rich in sodium and potassium possibly has some role in the genesis of the failure. In their survey, these cultural traditions and PPCF were commonest in Zaria, Kano, Malumfashi, Zamfara, Bauchi, etc.

As a young doctor we published and publicized the idea, to enlighten the community of practitioners and society at large about the possible harms of these traditions (Habib, 1992b), an archetypal Medicine, Science and Society concept. Subsequently, scores of researchers have been pre-occupied with PPCF: two of whom I have known – Professors Ayodele Falase (a former VC, University of Ibadan) and Kamilu Karaye. The latter graciously included me in his research team and rekindled my interest in Peripartum cardiomyopathy (PPCM), (Karaye et al, 2011). I believe they now recount several additional possible explanations to account for the ailment. Similarly, my long-term friend, Professor M. S. Mijinyawa involved me in his study of blood pressure and vital statistics among secondary school pupils in Kano, wherein I served as the bio-statistician (Mijinyawa, et al 2009). Subsequently, we have conducted several researches on non-infectious diseases on heart failure, hypertension, cardiac ventricular function and related diseases (Karaye and Habib, 2009; Karaye et al 2010; Karaye and Habib, 2013).

Another tropical disease we encountered and published here in Kano is the Juvenile Tropical Pancreatitis (JTP) – also referred to as Fibrocalculous Pancreatic Diabetes Mellitus. In this entity, children brought up on a diet of refined millet/maize pap 'koko' go on to develop calcium deposits in their pancreas which affect both alpha and beta cells thereby compromising insulin secretion with subsequent onset of ketosis resistant diabetes mellitus. These patients tend to be young having protuberant abdomen and swollen cheeks especially the parotid glands [Figure 3] (Abubakar L.Y. et al 2010). Mercifully with literacy, affluence and improvements in diet, JTP is now uncommon. As global health becomes more established NCD will become significant causes of health challenges worldwide in the future.

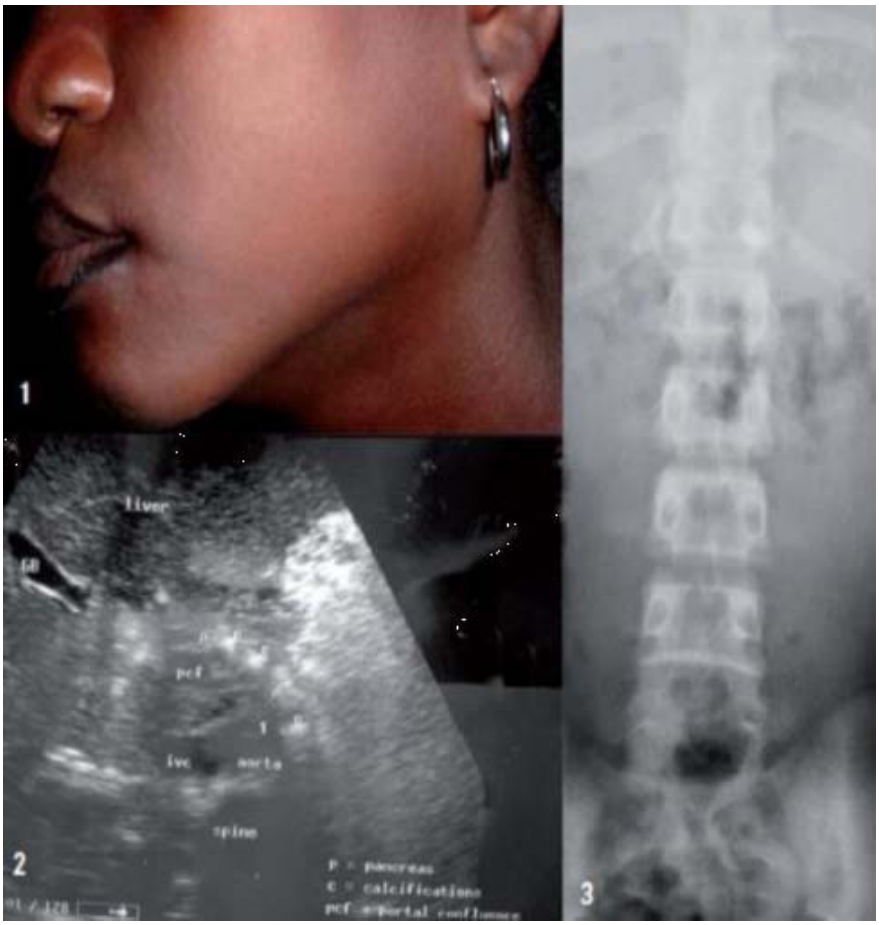

Figure 3: *Young Girl with Parotid Enlargement, Calcified Pancreas and Fibro-Calculous Pancreatitis Diabetes Mellitus FCPD (aka JTP*)

3.0 Epidemiology, Biostatistics and Mathematics

As a secondary school student, mathematics and physics were my best subjects and for which I got prizes in my final year. So naturally, during the course of my career, I became interested in epidemiology which is the scientific study of distribution and determinants of diseases utilizing descriptive as well as statistical or mathematical approaches. As a local investigator in an international multicentre clinical research trial for a new antibiotic 'oritavancin' used for resistant bacteria (MRSA), I earned some stipend. But at National University Hospital Singapore, there was a policy prohibiting staff to be given cash. So, I decided the money in thousands of sterling pounds should be given in kind and it should be

used to pay my tuition for masters in epidemiology and biostatistics in University of London's London School for Tropical Medicine and Hygiene (LSTMH).

In the course of my study, I got lucky that Dr Mona Jeffreys was my supervisor along with the deputy chief statistician for England and Wales – Professor Michel Coleman. They gave me data on anal and rectal cancer for England and Wales stretching from 1980s to early 2000s and running into nearly 150,000 patients. My research question was to identify factors predicting who will die or survive using advanced statistical techniques – **Relative Survival** and **Generalized Linear Model**. The data had information on socio-economic status using 'Carstairs Deprivation Scores', anatomic location of cancer, pathologic type of cancer, histologic type of cancer, year of diagnosis, year of death, etc. Bernard Rachet – a prodigious French cancer survival statistician – had to develop a new computer programme as an add-on syntax on the **STATA platform.** Of course, by then I was adept with STATA and statistics like chi-square, t-test, Mann Whitney U test, Wilcoxon rank sum, Linear, Logistic, Poisson and Cox regression were routine and common place. We were able to define which factors predicted survival cognizant of temporal trends, patient and tumour characteristics.

We showed that the 5-year relative survival was higher in women, younger patients and more affluent patients, and higher for anal cancer than rectal cancer. Survival improved by more than 10% from the late 1980s (around 38%) to the late 1990s (49%) (Jeffreys et al 2006). The trend was not explained by changes in the distribution of age, anatomical site, morphology or deprivation. The trend was more marked in younger and more affluent patients, and for adenocarcinoma and epidermoid carcinoma than for tumours with other morphology. The inequality in survival between affluent and deprived patients widened (Jeffreys et al 2006). Inequality in health would today be regarded a major pillar of global health research /practice! We concluded that improvements in survival may reflect improvements in disease stage, diagnostic technique or treatment. Which of these factors contributed to the widening socio-economic inequalities in survival, remains to be elucidated.

Later, coordinating and collaborating with many centres as director Institute of Human Virology Nigeria, we combined data on HIV infected patients from Abuja, Benin city, Kano and Nnewi, Nigeria to analyse nearly 6000 HIV infected patients using the same/ related technique of Generalized Estimating Equations (GEE) and Cox regression with STATA [Figure 4] (Charurat et al 2010). We found of the patients initiating ART, 26%

were Loss-To-Follow-Up (LTFU). Female gender ($p < 0.001$), post-secondary education ($p = 0.03$), and initiating treatment with zidovudine-containing ($p = 0.004$) or tenofovir-containing ($p = 0.05$) regimens were associated with decreased risk of LTFU, while patients with only primary education ($p = 0.02$) and those with baseline CD4 counts (cell/ml(3)) >350 and <100 were at a higher risk of LTFU compared to patients with baseline CD4 counts of 100-200. The adjusted GEE analysis showed that patients aged <35 years ($p = 0.005$), who travelled for >2 hours to the clinic ($p = 0.03$), had total ART duration of >6 months ($p<0.001$), and CD4 counts >200 at ART initiation were at a higher risk of non-adherence. Patients who disclosed their HIV status to spouse/family ($p = 0.01$) and were treated with tenofovir-containing regimens ($p <$ or $= 0.001$) were more likely to be adherent.

In conclusion, the findings formed the basis for implementing multiple pre-treatment visit preparation that promoted disclosure and active community outreach to support retention and adherence. It was surmised that expanding treatment access points of care to communities to diminish travel time would have a positive impact on adherence (Charurat et al 2010). Again, these approaches used **medicine, (statistical) science** to answer a **societal** knowledge gap to improve survival in cancer or HIV patients.

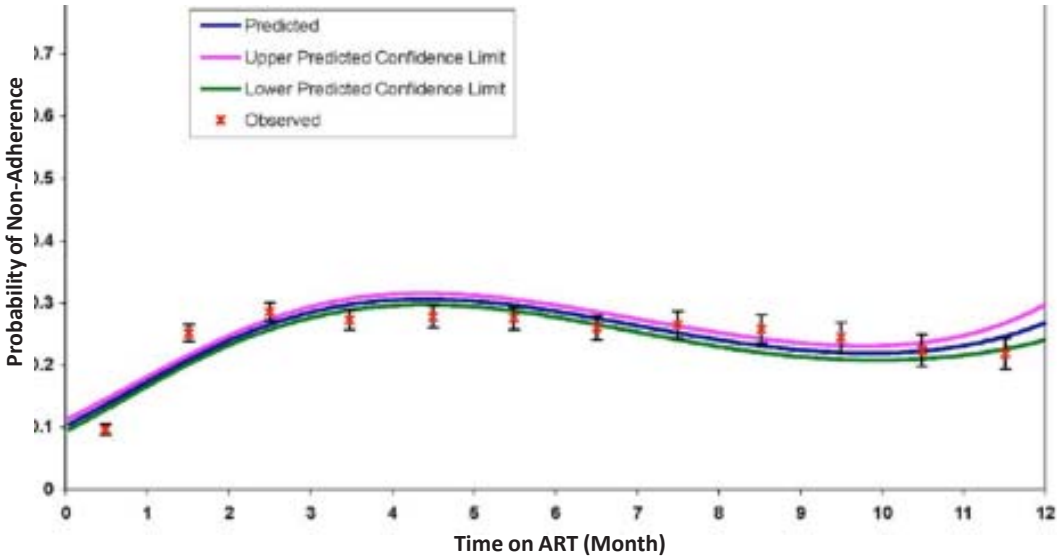

Figure 4: *Modelled probability of non-adherence within the first 12 months after initiating antiretroviral therapy among HIV patients* (Charurat et al 2010)

As it were, I had been interested in modules on Advanced Statistical Methods in Epidemiology from LSTMH which included **meta-analysis** – a technique of providing more precise estimates by pooling several sources or studies. It is used throughout the sciences and even in humanities. So, I tried my hands in applied meta-analyses and stimulated its early and broader use at Bayero University Kano. While I anchored the production of four publications: (Habib, 2011; Karaye and Habib, 2012; Habib and Warrell, 2013; Habib et al 2013). Eventually, BUK Groups/Units published over 14 and we are probably second only to University of Calabar in Nigeria in this area.

My colleague, Ahmed MaifadaYakasai has graciously involved me as a co-author in his works and is now a bona-fide expert with several publications on meta-analyses that he anchored (Yakasai et al 2014; Yakasai et al 2015). My four meta-analyses set out to answer important questions of public health concerns: two were on antivenom use in the world with one showing adrenaline premedication rather than antihistamines or steroids prevented early adverse reactions (Habib, 2011) and the second showing the exact protection conferred by antivenoms against death from carpet viper "Gobe-da-Nisa" is 75% in West Africa (Habib and Warrell, 2013).

Many authorities and institutions changed their recommendations for managing antivenom reactions following the former and a related Sri-Lankan study. Along with Professor Kamilu Karaye, we obtained probably the first meta-analysis burden estimates of cardiovascular diseases in Sub-Saharan Africa (SSA) on stroke, heart failure, hypertension, kidney diseases and lipid disorders [Figure 5] (Karaye and Habib, 2012). Lastly, together with my Unit Head, the amiable Dr Ibrahim Nashabaru, my brother Dr Zaharaddeen G. Habib, a psychiatrist, and other colleagues, we used meta-analysis to estimate the burden of cognitive impairment (dementia or memory impairment) in HIV infected patients in SSA showing that nearly 8 million of the 24 million HIV infected patients in SSA have dementia and that antiretroviral therapy mitigates it [Figure 6] (Habib et al 2013). Remarkably, our estimates are similar to that of Ned Sacktor's group from Johns Hopkins University working in Uganda who estimated over 7 million. As provost of the College along with colleagues, we conducted two or three trainings on meta-analysis to the staff to impart and facilitate its take-off.

With a desire to characterize outbreaks and epidemics, I attended infectious diseases mathematical modelling at MRC Centre for Outbreak Analysis/Imperial College London,

a speciality that uses principles of Bernoulli's fluid dynamics and calculus –largely formulating differential equations in how populations change within compartments affected during epidemics, then using integral calculus to resolve and provide estimate and projections of epidemics, and lastly to quantify the impact/effect of control measures. We have been collaborating with Dr Nafiu Hussain of mathematics to model Lassa fever outbreak in Nigeria (uncompleted). The last aspect of Advanced Quantitative Syntheses in Epidemiology that I have been interested and involved in is health economics and cost-effectiveness analyses using several applied mathematical principles such as Bayesian theorem of probability, Decision trees, Monte Carlo simulations and Markov modelling. I will discuss some of our works in this area later. Needless to say, these aspects of quantitative reasoning apply the same principles of studying ***Medicine using Science for Societal*** good. They are highly influential areas in health policy, global and international health.

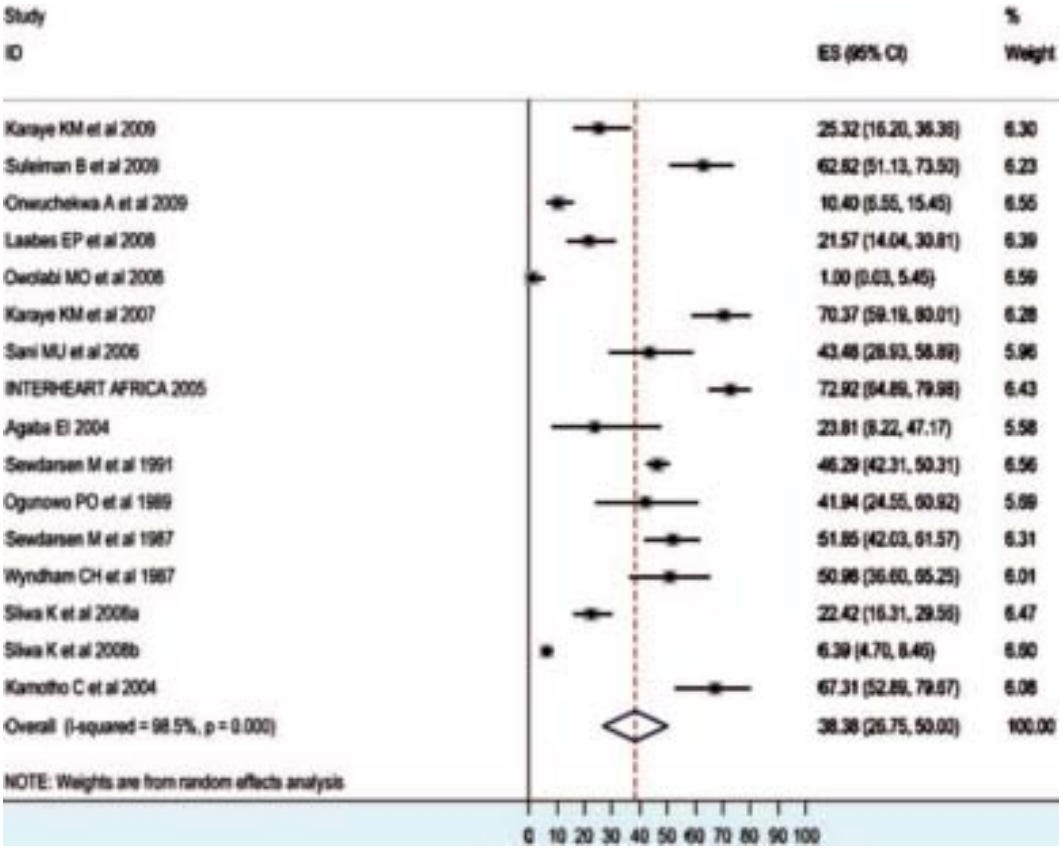

Figure 5: *Prevalence of Dyslipidaemia among Africans with cardiovascular diseases*

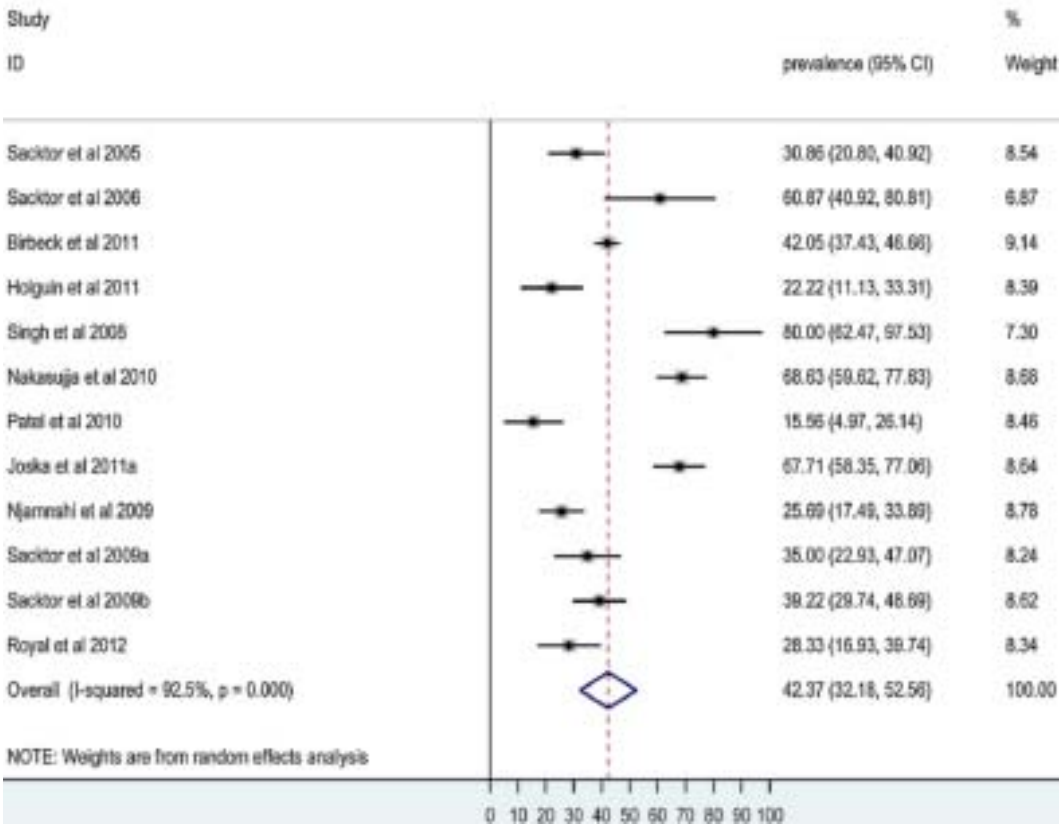

Figure 6: *Prevalence (%) of Neurocognitive Impairment in HIV Adults in Sub-Saharan Africa (off ART)*

4.0 Infectious Diseases, Microbiology, Antimicrobial Resistance and Infection Control and Prevention

As a group, we have researched and published on a number of bacterial infections highlighting their presentations, microbiology, management and prevention. These publications include but are not limited to: *Streptococcus agalactiae, (Methicillin Resistant) Staphylococcus aureus* (MRSA), *Salmonella typhi*, non-typhoidal Salmonellosis, Tuberculosis, Tetanus, *Klebsiellapneumoniae, Streptococcus pneumoniae*, Syphillis, Norcadiosis, meningococcal infections and the last on Melioidosis (unpublished) (*Habib et al 2000; Tambyah et al 2001; Habib, 2003a; Habib, 2003b; Habib and Tambyah 2003; Tambyah et al 2003; Habib, 2004; Chai et al 2005; Habib, 2009; Iliyasu et al 2009; Dayyabu et al 2014; Iliyasu et al 2014*).

Similarly, we have researched and published on viruses including: HIV, Hepatitis B, Hepatitis C, Cytomegalovirus, Rabies, Avian Influenza, Ebola and CoV-SARS (Habib 1995a; Habib 1995b; Habib et al 1998; Habib 2005; Tambyah et al 2003b; Singh et al 2003; Abdullahi et al 2010; Hamza et al 2013; Warrell et al 2013; Iliyasu et al 2015; Adeiza et al 2016).

I would like to state at the outset that although I have seen many clinical ID experts from different parts of the world, I have not come across any person as extra-ordinarily astute and gifted as Professor Mugbil Al-Hedaithy, during my stay in Riyadh and I learned very much from him. He trained in Canada, is modest, religious and even 'smells' the likely bacterial cause of infection, not only from the agar-plate but right from the patient in the ward!

All the infections mentioned made some impression on me and I encountered some of them in South East Asia (SEA) or elsewhere but all were instructive. Firstly, although the problem of multi-drug resistant so called Extended Spectrum Beta-Lactamase (ESBL) *Klebsiella pneumoniae* is universal and I have encountered it in Middle East, SEA, the UK and now Africa, the natural history of *Klebsiella pneumoniae* appears to be different in East Asia compared to the rest of the world. Presumably due to certain differences in ribotype the bacteria causes severe infections of the brain and its covering in East Asia as against elsewhere, and we did publish a fairly significant case series of brain abscesses, meningitis and sub-dural effusion from it (Habib and Tambyah 2003). As you may be aware a relatively new strain of the bacteria is even resistant to our last line antibiotic, the carbepenems. The carbapenem resistant New Delhi metalloproteinase (carbapenemase) *K pneumoniae* has been observed in Kano perhaps having been imported from India, possibly via medical tourism. This bacteria has been dispersed and threatens the world, partly necessitating a high level United Nations Security Council meeting and resolutions. Widespread resistance to antibiotics has been reported in Kano for over a decade (Habib et al 2003). Today antimicrobial resistance is one of the most important Global Health issues of our time.

The second bacterial infection, Melioidosis due to *Bukholderiapseudomallei* – a soil bacteria – or Glanders is almost solely restricted to Asia and tropical Australia other than few reported cases among travellers and migrants. To my knowledge, one case has been reported from West Africa. During my stay in SEA, I have encountered it as a serious

often life-threatening infection especially when it presents as a blood stream infection. In clinical infectious diseases practice, three infections can kill within 12 to 24 hours of acquisition – *meningococcaemia, Group A Stretococcal necrotizing fasciitis* and *Melioidosis*!

Thirdly, although I had published on tetanus complicating a tropical condition (Habib 2003b), it was with Professor Lukman Owolabi that we published a fairly large series, describing the determinants of mortality tetanus (Owolabi et al 2010; Owolabi et al 2011). While most countries have eliminated this toxin-mediated disease, it is still not uncommon in Nigeria. Hopefully, the Maternal & Neonatal Tetanus Elimination Programme will see to its control.

Fourthly, I reviewed and published on 50 blood culture proven cases salmonella infections, both typhoidal and non-typhoidal showing their many and varied manifestations (Habib 2004). An interesting but fatal case that made a lasting impression was of salmonella aorta aneurysm – large dilatation of the biggest artery – that formed a fistula (conduit) to the windpipe thereby leading to massive expectoration of bloody sputum and a helpless pitiful death within 24 hours (Habib 2003a). Incidentally, recent studies among children in Kano confirm that *Salmonella typhi* is among the most commonly cultured blood stream infection. Persistence of typhoid fever in our setting is a major health system and public health failure. Lastly, I recount our researches with two invasive infections with two – *Pneumococcus* and *Staphylococcus aureus*– bacterial infections. Both cause pneumonia and bloodstream infection, with meningitis (in the former) and metastatic deposit (with the latter) (Iliyasu et al 2015a*)*

Furthermore, *pneumococcal* and *staphylococcal* resistance is a major global challenge also encountered in Kano *(*Habib et al 2003; Iliyasu et al 2015b). In two illustrative cases: a 14 year old boy was brought from boarding school barely alive with pneumonia, severe blood stream infection and destruction of head of femur bone. Through a 2-month hospitalization, he survived and the father later confided in me that when he took him from the boarding school he phoned to tell the mother that the child was nearly dead and there wasn't any hope! In the second case, a 14 year old from boarding school was also brought with pneumonia, bloodstream infection and meningitis; at some point he was not seeing, not hearing and had half his body paralysed. He also, recovered fully after a 3-month stay in our team. Mercifully at NPHCDA and our – NITAG committee – immunization against

certain bacteria e.g., meningococcal vaccination, pneumococcal conjugate vaccine have been commenced and may reduce the burden of these diseases.

With Garba Iliyasu who has been steadfast in his interest in Healthcare Associated Infections (HAI) and Infection Control and Prevention (ICP), we have evaluated the situation in Kano. Our recent retrospective analysis of 76 patients with 84 HAIs admitted to the Intensive Care Unit (ICU) over a four-year period at AKTH-BUK showed that the most common infections were Skin-Soft Tissue Infection (35.7%) followed by urinary tract infection (27.4%). We found the most frequent isolates were *Staphylococcus aureus* (41.7%), *Klebsiellapneumoniae* (21.4%) and *Escherichia coli* (15.5%). High rate of resistance to cloxacillin (54.3%) and cotrimoxazole (65.4%) was noted among the S aureus isolates. However, all the Enterobacteriaceae isolates were susceptible to meropenem, whereas resistance rate to ceftriaxone was high (*E coli*, 55.6%; *K pneumoniae*, 71.4%; *Proteus*spp, 50%) (*Iliyasu G et al 2016a*). It appears resistance among respiratory and urinary bacterial pathogens in Kano is not a recent phenomenon as it had been present and widespread over a decade ago (Habib et al 2003).

Furthermore, we found conditions encouraging persistence of antimicrobial resistance still exist, as our retrospective audit of antimicrobial prescriptions spanning over a 6-month period showed that 49% of 412 patients admitted to medical wards were prescribed antibiotics with over a quarter having more than one antibiotic (Iliyasu et al 2015). An exceptional person who supported us in ICP at Kano is Mallam Salisu Abubakar. Earlier on, I was initiated into HAI and ICP by Paul Tambyah, one of the most hardworking people I have ever known. Together, we confirmed most MRSA in Singapore are healthcare associated and we also showed paradoxical rise in prevalence of MRSA during epidemics (Chai et al 2005). These topics typify the concept of ***Medicine, Science and Society, and their Global Health Implications***.

5.0 Tropical Medicine and Toxinology

Malaria remains a serious disease among the non-immunes such as children and pregnant women in endemic settings or foreign visitors to endemic tropical settings. In West Africa, *Plasmodium vivax* is not observed while *Plasmodium falciparum* is the main cause of infection and is a problem even among nomadic Fulani [Figure 1]. In Asia, however, *Plasmodium vivax* is a significant cause of malaria. We presented severe cases of vivax malaria in non-immune adults presenting with severe respiratory distress and lung oedema

(which is less common with falciparum malaria) imported from South East Asia. Mortality was high about 50% (Habib and Singh, 2004).

In a team of colleagues involving Professors Zubairu Iliyasu, Isa Sadiq and Drs Abdulsalami Yayo, Muhammad Hamza and Musa Bello, we undertook a community malaria intervention study. This was a fairly large study on malaria intervention that we conducted in a cluster randomized trial evaluating the performance of *Rambo* paper. The project was sponsored by Malaria Care Foundation, Gongoni and W.J Bush Ltd, the makers of *Rambo* paper. Two suburban villages *Danbare* and *Panshekara* were randomized to receive either the *Rambo* paper, made of tranfluthrin insecticide, or the standard of care. They were followed over 18 month time and the incidence of malaria, anaemia, frequency and types of indoor mosquitoes were obtained periodically to quantify the effect of the *Rambo* insecticide. The randomly selected households in both communities had their doors and windows covered with wire mesh and were provided with prompt antimalarials, soap, detergents and few other amenities. *Rambo* paper was found to be effective in reducing culicine mosquitoes and had modest effect (reductions) on anopheline mosquitoes.

Dr Yayo – our ace entomologist – collected mosquitoes from households in both *Danbare* and *Panshekara* and subjected them to circumsporozoite (CSP) antigen analysis using ELIZA and PCR techniques. The improvement in packed cell volume (a measure of how much blood an individual has) showed a marginal positive improvement in the communities/ households administered *Rambo* (Yayo et al 2014; Yayo et al 2016). Drs Hamza and Musa proved excellent in day-to-day running of the project. About the same time, Dr Hamza and the Infectious & Tropical Diseases Unit had just literally, by God's grace, saved a Polish exchange Hausa scholar from severe cerebral malaria acquired likely in Cameroons or South Eastern Nigeria for which a letter of commendation was given to him and the Unit.

My next malaria project is a collaborative work with physicists and engineers at a UK University and a commercial company who have developed a bracelet to diagnose and monitor malaria. Again it is based on flow dynamics and the changes that result when temperature rise, merozoite-infected red blood cells interact with capillary beds affecting adhesion molecules, rheology, viscosity and generation of hypoxia. Initial experiments suggest it may surpass both RDT and smears in the detection of malaria. It will be field tested here in Kano area.

At Bayero University Kano, both the current Vice Chancellor, Professor Muhammad Y. Bello and the former Vice Chancellor have supported our work at the Venom Antivenom Research Group (VASP) and I am happy to say on clinical epidemiology of snakebite research, I believe our institution should be ranked among the top half dozen units in the world doing similar work. The menace of snakebite is a major public health problem causing substantial morbidity and mortality in rural savannah West Africa with Nigeria being the most affected. The effect of poisoning is largely due to the venom injected following bite. Poisoning causes a variety of manifestations including pain, swelling, local bleeding, systemic bleeding, incoagulable blood and paralysis (neurotoxicity) [Figure 7].

As mentioned earlier, since medical student days, I have been interested and have written about snakebite. In addition to the immune-therapeutics that got me interested in it, there is the fact that the most impoverished members of society are the most affected. Our studies have characterized the epidemiology, burden of disease, clinical presentation (e.g., cardiac haemodynamics), determinants of outcome (e.g., causes of fatality), complications of bite (e.g., blisters) and the use of antivenom therapy. We have also identified the causes of deaths, poor outcomes, effectiveness and cost-effectiveness of antivenoms. Untreated about 20% of 'Gobe-da-Nisa' or carpet viper victims die and a sizeable proportion develop complications: amputation, scarring, blindness, pregnancy loss, etc. Delay to receiving antivenom also predisposes to death (Abubakar et al 2010; Habib et al 1995; Habib et al 2001; Habib et al 2008; Habib 2013; Habib and Abubakar 2011; Iliyasu et al 2014; Iliyasu et al 2015; Karaye et al 2012).

As recounted earlier, we facilitated the development of two new drugs (antivenoms) against Nigerian snake poisoning. Randomized Controlled Trial (RCT) alongside Meta-analysis are among the best methods for deriving good clinical evidence. RCT is the highest level of experimentation in clinical research and I am happy to say we conducted two in Nigeria; in the second one as usual a collective effort, Professor Isa Sadiq and I served as local co-principal investigators and corresponding author (Abubakar et al 2010a). Although I absolutely detest 'hero worship' or 'eye service', the overall leader is Emeritus Professor David A. Warrell of University of Oxford who is truly an inspirational figure and role model; he has been described as the 'Living Legend of Tropical Medicine' in an international medical journal. It remains the largest ever RCT in the field of antivenom therapy and toxinology in the world! These research endeavours are large and costly enterprises. I am happy to report that after several years, we found two antivenoms developed against three

Nigerian snakes (carpet viper, puff adder and cobra) out of 4 that were very effective and safe in preclinical and preliminary studies (Abubakar et al 2010b). The two products neutralized venom poisoning in 83% and 75% of victims within 6 hours of injecting it by restoring/normalizing blood clotting that had been deranged by the poisoning. The RCT wouldn't have been possible without our indefatigable hardworking colleague fully resident there for many years, Saidu B. Abubakar.

In the drug development of these two antivenoms, out of the 4 candidates, we have had to conduct experiments in mice to generate neutralizing dose of maximum snake venom yields. We also adapted a relatively new concept to do a modified dose-finding study the so-called '3+3' dose escalation design earlier tried in drug development for patients with advanced cancers. An immunobiologic argument ensued on whether Type I IgE-mediate immune hypersensitivity reaction and antivenom early advanced reactions are dose-dependent and positively monotonic or not? Few colleagues were critical and wrote a rejoinder but we successfully defended our position in a renowned journal that the approach we pursued was necessary and sensible (Habib et al 2010c).

Subsequently, my colleagues, notably Professors Isa Abubakar, Muhammad Gwarzo, Basheer Chedi and Drs Binta Kurfi, Muhammad Hamza, Garba Iliyasu and Hadeeza Lawal at VASP have been very innovative and we have conceived and conducted a number of ground breaking works some of which were partly conducted by postgraduate students. These have been presented at professional societies and or published. Later I co-edited a book on *Clinical Toxinology* published by Springer with Mahmood Dalhat and Ahamad Yakasai among the 30 authors (Figure 8).

6.0 Human Immunodeficiency Virus Infection (HIV)/AIDS and Tuberculosis

As a student of immunology and infectious diseases, these two diseases have been pivotal in my apprenticeship both as a medical doctor caring for patients and as a medical researcher. As a resident, I had reviewed what was then known of HIV/AIDS and then started to characterize its presentation in our environment. In a 1994-5 study, tuberculosis, acute bacterial infections, kaposi sarcoma and lymphoma were the commonest superadded co-morbidities. We were able to measure their CD4 cells and CD4/CD8 ratio using manual monoclonal antibody aided counts (Habib 1995a; Habib 1995b; Habib et al 1998; Habib

Figure 7: *Illustrative cases of 'Gobe-da-Nisa' or 'Kububuwa' carpet viper bite (Kaltungo, Nigeria)*

Figure 8: *Textbook co-edited and co-authored by Abdul Habib along with two of our Unit colleagues among the 30 authors and 636 pages*

2005). There was no flow cytometer and, at the clinic along with my boss, supervisor and Head, Prof Geoffrey C. Onyemelukwe, we treated patients with Levamisole as there wasn't antiretroviral therapy. In other words, we were seeing the natural history of untreated HIV/AIDS and of course, death toll was high! Therefore we characterized clinical conditions in more detail with colleagues in Surgery, e.g., Kaposi sarcoma, a cancer that afflicts these patients (Ahmed et al 2001). In those early phase, the prevalence of HIV in tuberculosis was initially low before it skyrocketed. Subsequently, the rate of HIV in TB rose manifold and the presentation became atypical. At some point, I reviewed the many and varied manifestations of TB co-existing with HIV infection.

Following Professor Mahmoud U. Sani's article that described the pre-treatment AIDS mortality in Kano around 2005, we became interested in syndromic presentations, mortality prognostication and management of HIV infected patients. To this end, we presented on Acute Neurological and Psychiatric Presentation (ANPP) in admitted HIV infected patients where opportunistic infections like tuberculosis, acute bacterial infections, toxoplasmosis, cryptococcal meningitis, toxoplasmosis and HIV Associated Neurocognitive Deficit (HAND)/dementia are the common etiologies (Habib ZG et al 2007). With Walter Royal and William Blattner, professors of neurology and infectious diseases and cancer epidemiology respectively, at University of Maryland, Baltimore, USA, we found 29% of Nigerian HIV infected patients have HAND or memory impairment suggesting nearly a third of our patients will forget, and even forget to take their medications (Royal et al 2012; Yakasai et al 2015)! Later, a similar estimate was obtained using a different test battery. This in turn will lead to antiretroviral resistance. We also studied the practicalities of antiretroviral therapy e.g., adherence and effectiveness in our setting.

In one such study funded by Doris Duke Charitable Foundation, we conducted an RCT comparing three forms of interventions among HIV patients in Kano: standard of care arm, a second arm which included daily reminders via alarm and follow-up calls from peer-educators, and adherence support by a home-based treatment partner; and a third arm which included second arm activities, plus home visits by peer-educators. We found high levels of viral suppression and low prevalence of drug resistance mutations (DRMs) were observed in this participating ART cohort in Northern Nigeria. Further, we found self-reported good adherence and optimal Rx refill rates were reported as significant predictors of VL suppression [Figure 4] (Coker et al 2015). In an interesting follow-up study on clinical and verbal autopsy we confirmed TB, poor adherence to ART and stigma

and unproven traditional medicines are commonest causes of HIV deaths in Kano (Iliyasu and Habib, 2015).

As Kano has a predominant Muslim population and in the spirit of addressing societal medical challenges, we have addressed certain issues of particular importance to our setting, holding the view no one will come from abroad to address them for us. For instance, we surmised that many countries with a considerable burden of HIV infection in Africa and Asia also have a substantial Muslim population and anti-retroviral therapy (ART) has led to reductions in HIV morbidity and mortality in those areas. However, for ART to remain durably effective its provision should be adapted to local and religious customary practices such as Ramadan fasting. That fasting is often observed by Muslims with HIV infection and ART might be compromised by sub-optimal adherence during fasting, as it precludes the ingestion of oral substances during the daytime and is often associated with an alteration of meals/sleeping patterns.

1). In the first scenario, we evaluated treatment adherence and customary practices in those first line ART – that is those on fairly simple and straight forward ART medications. We studied 142 Muslim fasting 'FT' and 101 non-fasting 'NFT' patients on ART in Kano, Nigeria. Using rigorous statistical analysis, we found adherence on ART among FT and NFT patients was similar during Ramadan, 96% and 98%, and ever since commencement of ART, 80% and 88%, respectively. FT patients altered their typical daily behaviours by advancing morning and delaying evening doses thereby prolonging dosing intervals, eating heavier meals pre-dawn and on breakfast at sunset (78%), and changing or reducing their sleeping and waking times (40%). The study suggests that adherence and drug taking frequency appear uncompromised in Muslim FT HIV infected patients on ARVs (Habib et al 2009).

2). In the second scenario, we evaluated adherence, performance of second line ART regimen, safety and effectiveness for those on second line ART i.e., those who have failed first-line. Generally these are more complicated medications. Among them we studied once-daily compared to twice-daily dosed ritonovir boosted lopinavir with fixed-dose tenofovir-emtricitabine once-daily among 17 heavily treatment-experienced stable FT patients in Nigeria. No changes in adherence, diarrhoea, CD4 cell counts, viral load, haematocrit, kidney, liver and lipid tests were observed. Again, we found effectiveness, safety and tolerability appeared unaffected by the Ramadan fasting (Yakasai et al 2011).

Since my days as a resident, I have been interested in tuberculosis referred in ancient times as 'consumption' or white plague. Indeed my residency dissertation was on its immunology. Subsequently on its various aspects as mentioned above. In addition to HIV, TB co-exists with other conditions like diabetes mellitus and cancer. I published on a fairly enlightening series of 37 patients with TB co-existing with cancer showing that TB can precede, simulate, co-exist, complicate cancer therapy. Occasionally the two may inhabit the lung lobe or segment. Mortality tended to be high (Habib 2005). We suspect pregnancy may also activate TB and presented few such cases (Habib ZG et al 2015). I believe the burden of TB on mothers and babies in SSA would be considerable and have been conceiving the best ways of providing a burden estimates.

Two incredible people I have the good fortune of knowing for long have also shaped my thoughts on TB. The first, Professor Idris Abdulkadir, a former executive secretary NUC, has been a *guardian, mentor and role model* from my Barewa College days and ever since. He is as disciplined and straightforward as he is punctual and punctilious. He was awarded an honorary doctorate degree by BUK few years ago. As a researcher, he has been working on TB in both cattle and humans and has authored a textbook on infectious diseases. He has co-opted me and we have published together. Also, I have co-supervised some of his PhD students on TB in cattle and humans in 6 states of north-eastern Nigeria (Ibrahim et al 2016a; Ibrahim et al 2016b).

The second person is a billionaire, academic researcher and friend, Professor Lovett Lawson. He initiated me into the world of multi-drug resistant (MDR) TB and we became among the first to publish on and show its presence in Abuja area (Lawson et al 2010). Subsequently, we have co-authored several papers on bovine TB and shown the significant problem of MDR TB in Calabar, along with Akan Otu who came to stay with me in Kano despite the Boko Haram menace (Otu et al 2013a; Otu et al 2013b). Recently, we audited the performance of Gene-Xpert and molecular science based tests in Kano (Mohammed A et al 2017a). Human societies have known and encountered TB for millennia and the two infections classically typify the theme of this lecture – medicine, science and society. Arguably these two diseases are of the highest global health concern.

7.0 Emerging, Re-emerging and Epidemic Infections

Epidemics and outbreaks may occur in regions and also within health facilities. New conditions may first appear in healthcare setting or in the community. An infectious disease

physician may train, work and even retire as an ID physician without ever seeing a new condition or infection! I was lucky or unlucky that while practising in Singapore sometime between 2001 to 2004, a new condition no one knew and no one knew the cause either, appeared. Sometime in 2003, it started appearing among patients manifesting as fever, severe shortness of breath, sore throat, cough and other less consistent features (Tambyah et al 2003b; Singh et al 2003; Ho et al 2004). Tests for the likely usual common causes all proved negative. Initially it started in Hong Kong [Figure 9], then spread within days to surrounding countries including Vietnam – where it killed the WHO staff, Carlo Urbani – who had started fighting it. Panic was rife and common place reminding one of Daniel Defoe's description of arrival of plague into London. A name was coined for the condition – Severe Acute Respiratory Syndrome (SARS). South East Asia is a region used to new diseases and was recovering from emergence of Avian Influenza [AI] (H5N1) virus in Hong Kong in 1997 and from Nipah virus in Malaysia and Singapore in 2000. So, initial suspicion was that it could be AI, Nipah, bat-transmitted or even Hendra virus; however, all their tests proved negative.

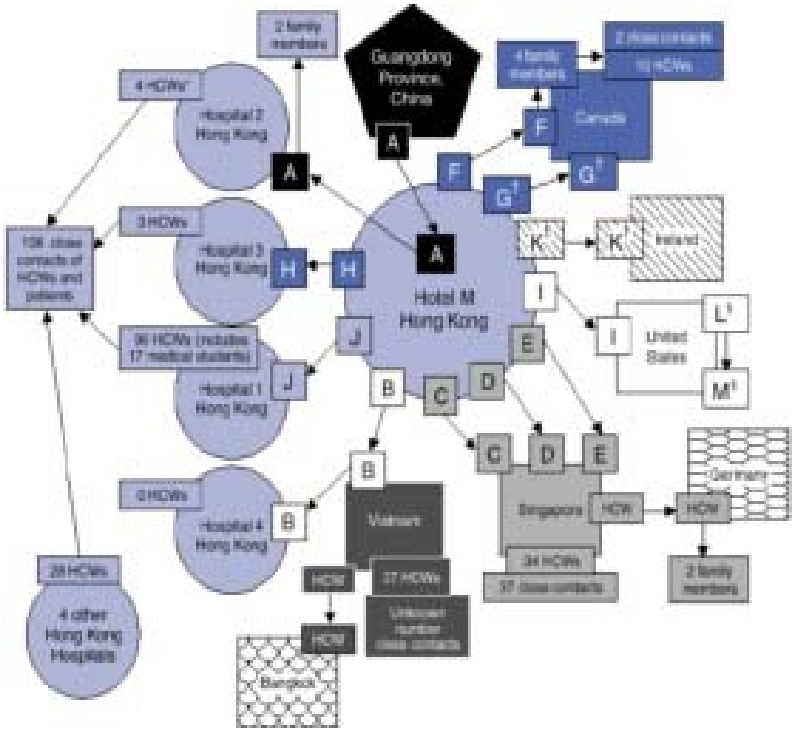

Figure 9: *Dispersal of SARS from Metropol Hotel Hong Kong to the rest of the world (**Source:** CDC)*

Not only was it in Singapore, but a highly respected Intensivist/Pulmonologist, Dr Lee Kang Ho, whom I happen to know very well in our hospital, National University Hospital (NUH) - had gotten infected whilst doing bronchoscopy and was fighting for his life! We soon realized the new disease had much appetite for healthcare workers and was easily transmitted from patients to staff, so called nosocomial propensity just like Lassa fever. So, NUH was as much a hospital as it was a battle ground and I was in the middle! Initially, the three of us, ID physicians and Pulmonologists had to manage the whole hospital and one went for days without sleep as each patient coming to the hospital had to be triaged, certified, Okayed for admission and assigned areas/wards of the hospital. We were all getting scared and remarkable arrangements were put in place. Within those circumstances, we had to research the initial presentations, characteristics, laboratory investigations and outcome of patients. As the outbreak was raging, a new virus was identified from wild animal wet market, where civet cat was found through epidemiologic studies, to harbour it. It belongs to the DNA group of viruses, the Corona Virus family, and the Oseltamivir and earlier on, Ribavirin we had been using wouldn't mitigate it! The Institute of Molecular & Cell Biology (IMCB) based at National University of Singapore (NUS) had developed diagnostic tests in record time. Before the test came into being, we depended on the WHO Case Definition but before long, we found it was not wholly reliable [Table 1]. We went ahead and published our analysis of the WHO criteria and its performance in our hands, and had to modify and exercise caution in utilizing it (Tambyah et al 2003b).

	SARS	**Non-SARS**	**Total**
Initial WHO criteria +	5	42	47
Initial WHO criteria -	13	896	909
Total	18	938	956

Table 1: *Performance of the WHO Case Definition in SARS Epidemic. Sensitivity 27.8% (95% CI: 9.7% to 53.5%), Specificity 95.5% (95% CI: 94.0% to 96.8%), Positive predictive value 10.6% (95% CI: 3.6% to 23.1%), Negative predictive value 98.6% (95% CI: 97.6% to 99.2%).* (Tambyah, Singh, Habib, BMJ 2003b)

As the civet cat was asymptomatic even where it harboured the virus, fear was lurking that perhaps there were asymptomatic or minimally symptomatic human cases that may be transmitters in a setting, more like informers in Albert Camus' *The Plague*! Mercifully, when we conducted a large survey this wasn't established (Ho et al 2004). Within weeks, the Mathematical Modelling Group/MRC Centre for Outbreak Analysis at Imperial College London under Sir Roy Anderson *FRS* had modelled SARS, got its Basic Reproductive Number around 2.7 - 3.3, and also obtained the likely impact of a set of potential containment measures highlighting the most effective approaches.

Many public measures such as quarantine, school closure, telemetry for contacts, social distancing measures, airport fever scanning, etc were introduced. As doctors, we had to record and submit our temperatures twice a day on an online platform and will be furloughed if feverish. Costly but effective barrier precaution measures were instituted among healthcare workers in hospitals and they succeeded in curtailing transmission [Figure 10]. A single hospital spent $20,000 on personal protective equipment daily at the peak of the outbreak!

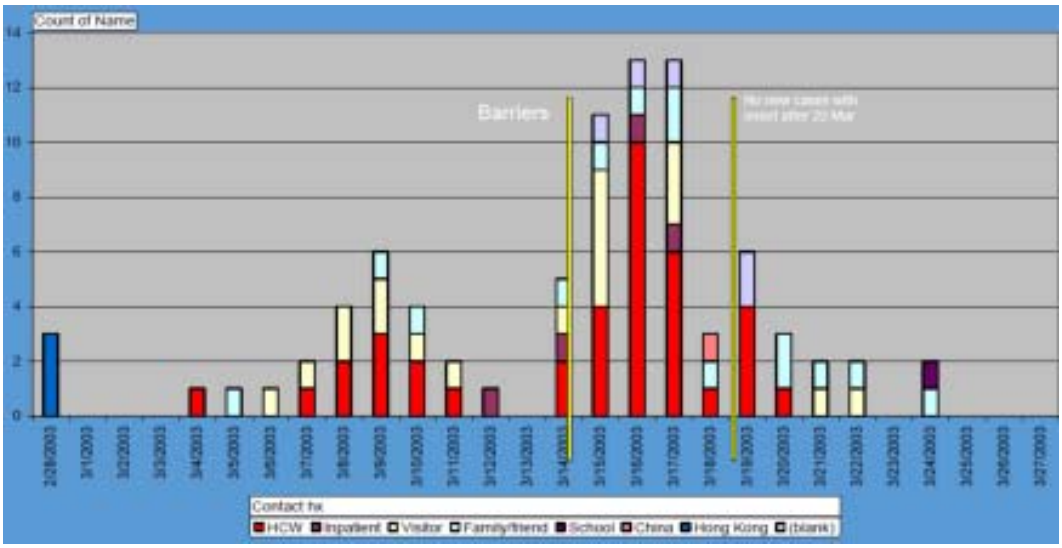

Figure 10: *Depiction of effectiveness of barrier precautions among healthcare workers against SARS at National University Hospital Singapore (unpublished, personal records)*

An ID colleague, Dr Hoe Nam, who travelled to the US fell sick and his commercial jumbo flight had to be diverted *en route* to Frankfurt as he fell sick with florid SARS and was admitted at a high containment facility in Hamburg, Germany. My family and I were constantly afraid that I would import it into our home or that someone would be infected while I was away. I was invited by the Hospital Infection Society (UK) and the Indonesian Infection Society to go and enlighten on SARS and have had to travel to London and to Surabaya, Indonesia. Later, I had to be away to New York and leaving my wife **Fatima** and children in a distant land in times of an epidemic wasn't easy as Nobel prize winning author Gabriel Garcia Maquez would proclaim in his book *Love in Times of Cholera*! Certainly it was a challenging time but no less exciting. It caused enormous economic loss to South East Asia running into tens of billions of dollars. It is unforgettable and I have learned much from it beyond measure!!! I was privileged to work with an absolutely brilliant, charming, understanding and exceptionally hardworking character - Paul A. Tambyah as a colleague and friend. Now a professor, he has renewed his promise to train for 6-12 months ID Residents *pro bono* in fact paying their air travel and accommodation while in Singapore.

An earlier outbreak that we encountered was with a previously mentioned drug resistant bacteria, Extended Spectrum Beta Lactamase (ESBL) *Klebsiella pneumonia (Kpn)*. It emerged and spread throughout the hospital causing more harm. In particular, such hospital bacterial outbreaks lead to longer hospital stays, superadded diseases, use of potentially more harmful antibiotics, and increased hospital cost. The outbreak affected 84 patients and we used double disc diffusion and pulsed-field gel electrophoresis (PFGE) with *SpeI* digestion for molecular biologic and epidemiologic characterization of the bacteria. We developed dendrograms from the PFGE analysis which revealed only 8 minor clusters of 2-3 strains with a genetic similarity of at least 70%. The vast majority of isolates (79%) were genetically unrelated including 72% of the ESBL producers. We concluded that molecular evidence of genetic diversity confirms clinical and epidemiologic data showing the absence of a common source outbreak (Tambyah et al 2001). In the future, molecular biology will be increasingly used in characterizing and containing epidemics and in global health.

From 2006, I have had the privilege of working in Epidemic Preparedness and Response (EPR) committee at state level and have advised the Presidential Advisory Committee on Bird Flu. During the 2009 meningococcal meningitis epidemic, I chaired the EPR committee

at AKTH where we had 222 patients of which 14 died giving a Case Fatality Rate of 6-7% [Figure 11] (Iliyasu et al 2009).

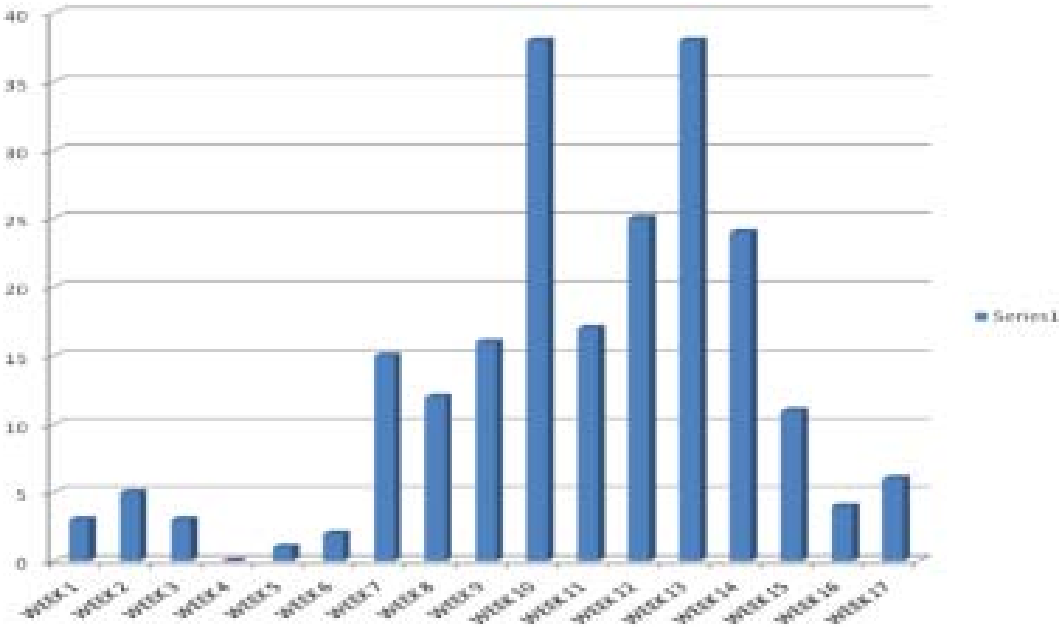

Figure 11: *Epidemic curve for Meningococcal Meningitis at AKTH Kano, 5 Jan-15 May, 2009* (Iliyasu, Lawal, Habib, et al 2009).

All the varied manifestations of cerebrospinal meningitis (CSM) were observed: neck stiffness, fever, rash, purpurafulminana, clustering of cases and deaths, and immune complex joint affectation among those who recovered [Figure 12]. Appropriate control measures were administered including case management with antibiotics, prevention among contacts using antibiotics and mass/targeted vaccination in communities. The disease is caused by a bacteria called *Neisseria meningitides* and has different serogroups – A, B, C, X, Y and W135 being the commonest causes. Recently, we have reviewed all the epidemics of CSM and found that serogroups A and W135 have been the commonest cause of outbreaks in the West African savannah lately (Mohammed I et al 2017b).

It was suggested that returning pilgrims around 1900 introduced the disease to Nigeria and it appears probable that W135 was also introduced to Africa by returning pilgrims around 2000. Serogroup A is by far, the commonest cause and from 2010 - 11, a massive international vaccination campaign sponsored by Bill & Melinda Gates Foundation, WHO

and PATHS against serogroup A was undertaken with eventually over 260 million people vaccinated in West Africa.

I have been a member of Nigerian Immunization Technical Advisory Group (NITAG) advising the Honourable Minister for Health and the NPHCDA and by the end of June 2016, 89 million people were vaccinated against serogroup A in the country. Serogroup C caused disease in Nigeria nearly 40 years ago and was last seen in West Africa in Upper Volta (Burkina Faso) in 1979! Since the massive vaccination campaigns, disease due to A has disappeared but recently serogroup C has now re-emerged causing outbreaks in Nigeria's Kebbi, Sokoto and Zamfara States. This year, it has been severe especially in the latter state. Late last year, Stephen Obaro and I wrote in the Lancet Infectious Diseases cautioning on the need to pre-empt occurrence of disease from non-A serogroups and place control measures including consideration of quadrivalent conjugate vaccination with A, C, W135, Y especially as it had even caused outbreak in Niger Republic (Obaro and Habib, 2016). Lo and behold, this is what is happening now!

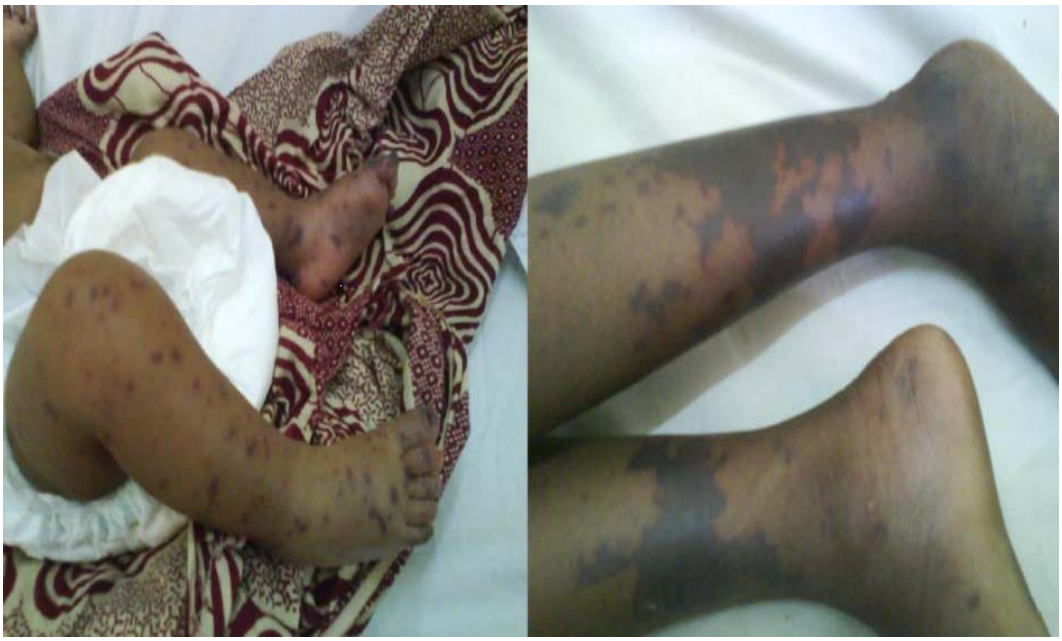

Figure 12: *Dissemianted Petechiae, Fulminant Purpura and Vasculitides during epidemic of Meningococcal Meningitis in Kano. Likelihood of dying may be over 50% with Purpura Fulminans* (Courtesy: Drs Fatima Hassan-Hanga and Lawal; Iliyasu, Lawal, Habib et al 2009).

Although Ebola Virus Disease (EVD) did not arrive Kano, but we conducted a number of enlightenment and sensitization activities given the level of panic, misconception, misinformation and its significance. At a point, the WHO—proclaimed EVD a Public Health Emergency of International Concern (PHEIC) because of its public health, economic, security and strategic implications. Such conditions are major regional and global health challenges. The state government was sensitized and dedicated facilities were prepared for EVD and Lassa fever. We also conducted a KAP study with Professor Dimie Ogoina (who is my vice president at Nigerian Infectious Diseases Society) and found substantial gaps even among healthcare workers. Our results reveal suboptimal EVD-related knowledge, attitude and practice among adults including healthcare workers in Calabar, Kano and Yenagoa, Nigeria (Iliyasu et al 2015). To effectively control future outbreaks of EVD in Nigeria, there is a need to implement public sensitization programmes that improve understanding of EVD and address EVD-related myths and misconceptions, especially among the general population.

The bird flu, H5N1 avian influenza virus in Nigeria remained largely within the poultry industry with only one human case reported in Lagos. It wreaked much havoc on chicken and there has been much economic loss. There is fear it will become easily transmissible and acquire pandemic potential. Our survey on it with my wife Maryam I. Abdullahi also showed lapses in KAP towards it. These were brought to the attention of the few advisory boards I served on regarding it (*Abdullahi et al 2010*).

8.0 International Health, Migrant and Travel Health

As Kano has a large Muslim population and in the spirit of addressing societal medical challenges, we continue to address certain issues of particular importance to our setting holding the views no one will come from abroad to address them. We surmised that many countries with high prevalence of HIV infection also have substantial Muslim populations who travel to Hajj in Saudi Arabia and they may encounter challenges regarding their ART medications. Further, at the time, Saudi Arabia and 20 odd countries bars entry to and repatriates those known with HIV infection. We evaluated how our pilgrims were affected working with our Nursing colleagues (Nurse Murjanatu Abdulmumini) and our counsellor (Hajiya Barakah)who followed the patients to the Hajj pilgrimage. In a cohort study in Kano, Nigeria, 31 clinically stable patients on ART who were travelling for the 2008 to 2009 Hajj (Hajj-pilgrims [HP]) were selected and compared with 27 consecutively selected

Muslim patients who were clinically stable and travelled to and from distances within the country to access ART (non-pilgrims [NP]).

Participants were clinically evaluated and interviewed regarding their adherence to ART pre-travel and post-travel, international border passage with medications and reasons for missing ART doses. Post-travel change in CD4 counts and RNA-PCR viral load were measured. Outcomes were proportion who missed at least 1 dose of ART during Hajj compared with pre-travel or post-travel. While failure of ART was defined as decline in CD4 cell counts or high viral load or both. We found the 31 HP and 27 NP had similar characteristics and were away for (median [range]) 36 days (28-43 days) and 84 days (28 - 84 days), respectively ($p < 0.0001$). Those who missed >or= 1 ART doses among HP and NP while away were 16/31 (51.6%) and 5/27 (18.5%), respectively with risk ratio (95% confidence interval [CI]) 2.79 (1.18-6.60). Among HP, the proportions who missed >or= 1 ART doses pre-travel and post-travel were lower than those who missed it during Hajj. Those who failed ART among HP compared with NP were 15/31 (48.4%) and 5/27 (18.5%), respectively with odds ratio (95% CI) 4.13 (1.10-17.21).

Reasons for missing ART included forgetfulness, exhaustion of supplies, stigma, spiritual alternatives, or disinclination; five patients were unable to cross airports with medications. We concluded that patients who went on Hajj were more likely to miss medications and to have ART failure due to several reasons including inability to cross borders with medications **(**Habib et al 2010**)**. For us, it is counterintuitive for governments to discourage visitors having access to their medications. An untreated infected patient compared to one on medications is more likely to transmit the infection in the country he is visiting. This is an issue of international health concern and affects many other conditions. There is need to disseminate and sensitize about similar issues more widely.

We have also studied health and medical conditions of travellers, not necessarily to Hajj. In one instance, we described acute onset long haul in-flight confusion, restlessness, disorientation and abnormal behaviour in a 24 year old lady who had typhoid fever. Confusion in travellers within the context of infections, including typhoid psychosis, 'culture shock' and other causes, was discussed to enlighten practitioners on the problem, and ensuing potential medico-legal and ethical issues (Habib and Tambyah, 2004).

As a Unit, we have been interested in health and well-being of vulnerable populations: homeless, migrants, mobile, street and nomadic people where health disparities abound. This falls within global health remit. Following a visit, by Professor Withers, a professor on street/homeless people medicine, we were led by Professors Lawal Abdu and Shehu Yusuf in exploring the health of sixty five (65) street people (adult almajirai and some lepers from Kano Golf Course and Race-course area). The subjects were examined though 7 had declined. There were 16 males and 49 females M:F=1:3). The mean age was 48 + 9.2 years. They were mainly widows, some live in the street and have no access to basic amenities and 6 use non-narcotic medicinal substances. Diseases observed are hypertension, visual problems, and trauma. We concluded that socio-cultural factors, and lack of government policy leads to poor access to health care for street people (Lawan et al 2013).

We have been interested in the health and well-being of nomadic Fulani, their livestock and the concept of "One Health". In a study entitled: "*Migration, Pastoralists, HIV Infection and Access to Care: the Nomadic Fulani of Northern Nigeria*" we discussed the burden of HIV infection among them. We surmised that migration–a way of life for them–is known to increase the rate of HIV transmission and may limit individuals' access to treatment and care. We appreciated that "*puulakou*" may dissuade and reduce risks though many of Africa's other traditional, pastoral societies are similarly affected. The paper explored cultural practices and factors among the Fulani that may influence HIV transmission, vulnerability to infection, sustainability and challenges to treatment access, and avenues and models for outreach services. Lastly, we proffered some solutions and recommendations. Cases of Fulani nomads with HIV were presented to illustrate the challenge of providing a care continuum as well as to demonstrate successes when appropriate HIV interventions are employed.

In addition to HIV, we have further confirmed presence of other infections, Bovine tuberculosis and possibly Brucellosis in both the pastoralists and their cattle herds in Rano, Kano [Figure 13] (Bello et al 2015). Patient interviews provide valuable insight and information on living and coping with HIV [Figure 1] but community mobility limits opportunities for counselling, testing and diagnosis, as well as HIV-related care access and maintenance. Consanguinity and certain cultural practices among the Fulani have clear amplification potential for HIV transmission. Treatment support through the use of coaches and life partners improves adherence to antiretroviral therapy (ART). Existing programmes

for nomads afford opportunities for absorption and integration of HIV services. Nomadic communities should be provided with basic HIV-related services, including risk-reduction education and methods, counselling and testing, ART, medication adherence counselling, access to laboratory tests and health monitoring (Habib and Jumare, 2008).

However, in addition to infectious diseases, increasing urbanization and socio-economic pressures place nomads in transition to urban and 'Western' lifestyles. Together with Professor Karaye and Dr Baffa Gwaram, we have surveyed non-communicable diseases among 214 semi-nomadic Fulani. It was found hypertension was common (29%) among them although awareness and treatment were low (Karaye et al 2015). In the second case, the prevalence of Sickle Cell gene and malaria were found to be not insignificant (in press). We have also shown the challenges of immunization among such pastoral nomadic populations and the difficulty of eradicating certain infections in hard-to-reach groups (Musa et al 2016).

We concluded healthcare services should be taken to nomadic communities using novel approaches such as mobile units, extension services, case management, directly observed care, and treatment supporters linked to neighbouring health facilities in a hub-and-spoke model. Stronger collaborations are recommended between programmes for nomads and HIV services, and also between veterinary (animal) and public health services – a 'One-Health' approach. Community participation and leadership should be encouraged to ensure the sustainability of HIV-related care delivery. At the end, we believed more research is needed on the epidemiology and sociology of HIV infection and the best ways to provide services to hard-to-reach nomadic populations.

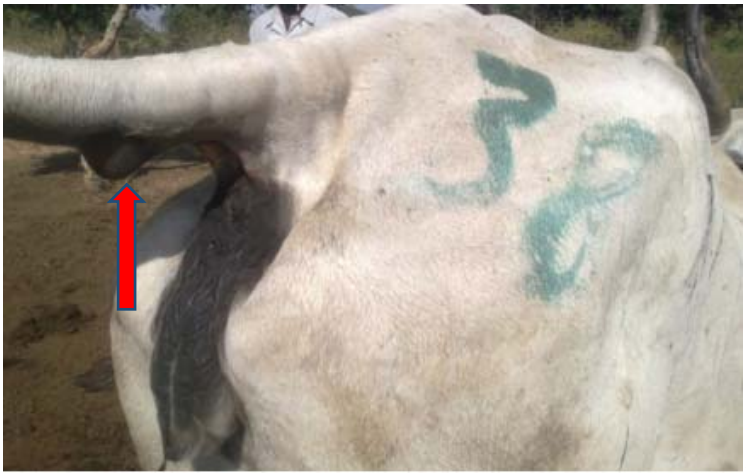

Figure 13: *Tuberculosis detection showing intradermal tuberculin test positive result beneath the tail – Rano, Kano*

9.0 Health Economics and Outcomes Research

Although I had an interest in health economics and cost-effectiveness analyses and have previously attended courses on it in London and Singapore, it was an introduction by Mohammed Lamorde, Head of Research at Infectious Diseases Institute, University of Makerere, Uganda, to Andreas Kuznik that spurred and actualized our conducting economic valuations of some interventions in infectious and tropical diseases. Firstly, with his guidance, I conducted a cost-effectiveness analysis (CEA) of antivenom therapy for Nigeria and on publication, it proved highly influential in the toxinology world and among Neglected Tropical Diseases experts (Habib et al 2015).

Secondly, Lamorde and Kuznik invited me to conduct an evaluation of burden of syphilis in pregnant women and its effect on neonates and how it leads to stillbirth. As it turned out, we found that Sub-Saharan Africa loses many babies to syphilis as stillbirths, and still many more are born with other adverse effects such as premature births, neonatal death and congenital syphilis with birth defects simply because pregnant women are not tested at antenatal care (ANC) or not treated when tested and found positive even though there is a point-of-care test that may give result at the same ANC attendance. Further, a single dose of a cheap antibiotic – Benzathine Penicillin – is curative in most cases and can be administered at the same ANC attendance. We computed the burden of loss, quantified as Disability Adjusted Life Years (DALYs). The DALY metric is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death.

In terms of our study, we computed syphilis burden for each of 43 countries in SSA. Overall, we found there are 206,000 adverse pregnancy outcomes due to syphilis and this translated to 12.5 million DALYs lost in Africa annually. The countries with the greatest loss from high to low are Congo, Nigeria, Ethiopia and Tanzania, with Benin having the least loss. Also, it is cheaper to control in the high prevalence countries [Figure 14]. As we computed the DALYs lost due to stillbirth, I couldn't help but compare that with what obtains in Islam where a stillbirth doesn't inherit and one may infer has no productivity *per se*. In our study, bioethicists and reviewers insisted a stillbirth also has lost productivity valued at a loss of potential 91years (Kuznik et al 2015)! There is clearly a gap for implementation scientists and public health practitioners to avert the loss and the cost. To avert a DALY appears to vary with the prevalence of syphilis.

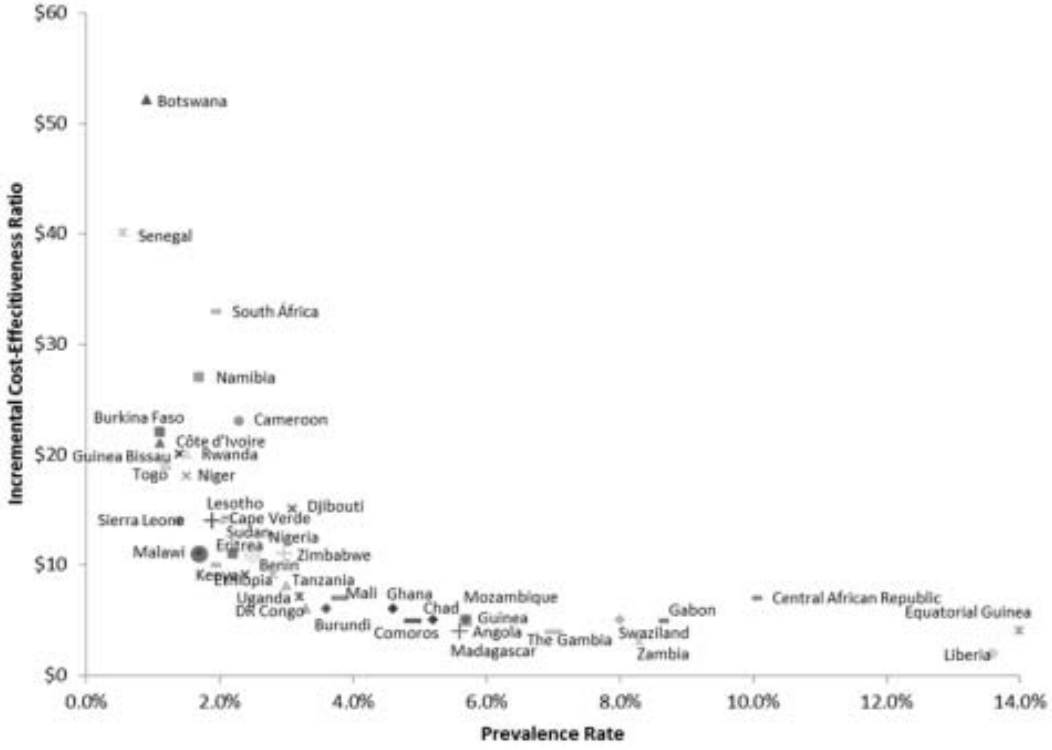

Figure 14: *Cost to avert 1 DALY from maternal syphilis for African countries*

Thirdly, we next explored the Carcinoembryonic antigen (CEA) by widely introducing New-Born Screening (NBS) for Sickle Cell Disease in each of 47 countries in SSA. NBS has been shown to confer survival advantages. Again, we found NBS would be cost-effective to introduce in many of the countries including in Nigeria with the highest burden of sickle cell disease although it wasn't cost effective in some countries with very low prevalence of the disease (Kuznik et al 2016). It became clear health economics is an extremely important tool in advocacy and health promotion, used towards changing health policy and practice, and in global and international health. Furthermore, with minimal investment, it could spur an institution's academic contributions to society, impact, rating and visibility.

So, realizing this and as Provost of the College of Health Sciences, I justified to the then Vice Chancellor, Professor Abubakar A. Rasheed, and an adjunct professorship was given to Andreas. On his arrival, a multidisciplinary group drawn from the wider University environment (Community Medicine, Economics, Medicine and Pharmacology) coined and formed **Health Economics and Outcomes Research Group (H-CORE)** to spearhead similar researches. To facilitate sustainability, the committee comprised both senior and junior colleagues. Needless to say, members of the group went on to publish insightful works that proved highly influential. For instance, Dr Hamza and I expanded our CEA on antivenom to cover each of the 16 countries in Western Africa showing that antivenom is highly cost-effective and saves productive lives and limbs in all the countries (Hamza et al 2016). It turned out to be more cost-effective than even antiretroviral therapy in certain scenarios in West Africa.

Dr Musa Baba Maiyaki, who has been working on multi-drug resistant tuberculosis (MDR-TB) decided to explore home *versus* institutional treatment of MDR-TB in a cost-optimization analysis and showed there will be savings in managing it at home (Musa et al 2015). Sometimes in 2015, while attending a meeting in Switzerland, the World Health Organization pronounced that it will immediately change its recommendation for starting HIV treatment to start in all with HIV (i.e., even very early mild disease) regardless of severity. The decision followed an important HIV-AIDS study published that week showing that it is much better and more helpful to patients to start antiretroviral therapy in those with mild or relatively early disease than to wait until HIV-AIDS has reached certain level of severity (previously when the CD4 cell counts has declined to less than 350 per cmm). Immediately, even before I returned, members of the **H-CORE** notably, Garba Iliyasu

and the ever watchful Baba Maiyaki were asking if it would be cost-effective especially in developing countries. In such resource-constrained settings, it means many more HIV patients needed to be commenced on treatment and a country like Nigeria consistently always had over 50% of those needing treatment but not getting it! So now, with this recommendation, it would mean over 75% of those needing treatment will not be able to get it! When eventually a CEA was conducted comparing whether to treat those with mild disease *versus* those with advanced disease cognizant of their expected life span, superadded infections and conditions, it was shown that it would be cost-effective in Nigeria, Uganda, South Africa but less so in India (Kuznik et al 2016).

Lastly, we computed the total burden of snakebite, i.e., premature deaths from snakebite and attendant limb amputation among survivors and found that it is substantial in DALYs much higher than what the Global Burden of Diseases (GBD) reports. In publishing the work, Dr Bashir Chedi a member of **H-CORE** and I, crafted a graph that proved highly influential beyond expectation. On the graph, we showed the burden of 10 top Neglected Tropical Diseases (NTD) in West Africa and how the world has provided money in dollars per DALY for each NTD. We showed for instance that the highest burden diseases of the most impoverished people didn't always get commensurate amount of resources or money to their burden e.g., schistosomiasis, rabies, snakebite, etc while the least burden diseases (diseases that rarely kill) e.g., trachoma, leprosy, buruli ulcer, dengue etc. get more money per DALY [Figure 15] (Habib et al 2015). This caused some excitement and WHO invited me to a meeting on 'reaching out to the bottom one billion people'. Subsequently, Mr Kofi Annan also invited few of us to explore how best to improve snakebite care in Africa and mobilize the international community.

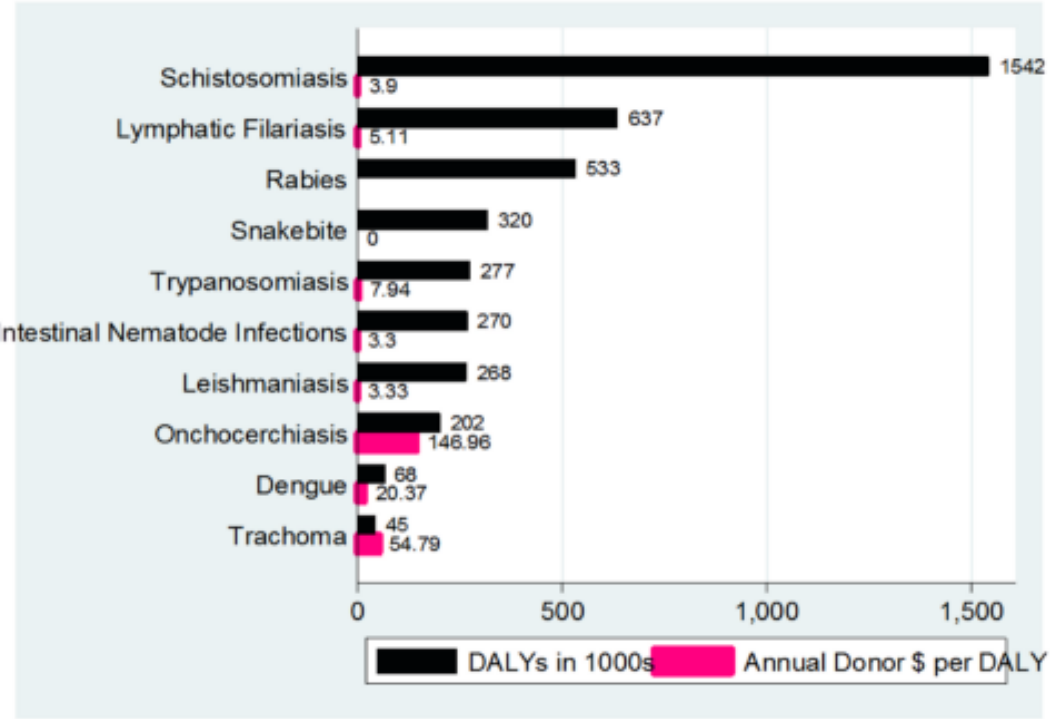

Figure 15: *Burden of NTDs in '000 DALYs and Annual Donor $ Funding Per DALY in West Africa* (Habib et al 2015)

10.0 Dissemination, Implementation and Public Health

All research should be disseminated and translated for implementation as policy and practice. I had the opportunity of working as director, medical services at an HIV implementation organization, the Institute of Human Virology Nigeria (IHVN) of the University of Maryland, USA. They had an annual budget of over $50 million while I was there. My colleagues and I were able to operationalize and implement many of the findings from researches. At a time, it was largely my responsibility as director, medical services, along with the energetic chief executive officer, Patrick Dakum, to provide and ensure quality of care for over a third of all Nigerian HIV patients. For instance, while it took me hours or days and unknown hardship to obtain CD4 cell count manually using monoclonal antibodies in early 1990s, at IHVN we were able to provide automatic flow cytometres for these measurements which eased and hastened care of HIV-infected patients in over 30 facilities across the country. We were able to orchestrate and provide Home-Based Kit for patients, which included many items that have been scientifically proven to be beneficial or even to improve survival

among the HIV-infected, e.g. co-trimoxazole prophylaxis, loperamide for diarrhea, albendazole de-worming, insecticide-treated nets, specific ART regiments, nutritionally-fortified meals, etc.

We were still able to maintain clinical meetings and when we observed that a research had shown Tenofovir-containing ART is a better regimen, we had to switch to it to ensure Nigerians got the best! We also called a meeting of all our teams throughout the country and taught on how to switch from one to the other. Mobile vehicles with HIV testing and mini-laboratory capacities that we had theorized for hard-to-reach nomadic Fulani and other populations were eventually obtained and distributed throughout the country. Occasionally, however, I would get a call that stock-out is imminent in Calabar, Benin, Sokoto or Azare – also my hometown; so, I had to be involved with procurement all the way from different parts of the world, and implemented what was desirable. However, in a public health programme, I learnt you cannot always have the best intervention that you would have insisted on when managing individual patients. Also, one has to adapt and be resilient to the way different cultures perceive and do things to resolve challenges [Figure 16]. The same old principles of advocacy, social mobilization, promotion, etc are needed to get things accepted and done. Fortunately, I was also backed by a team of great colleagues – Drs James Shepherd, Usman Gebi, Jibril Jumare, Mahmoud G. Jahun, Timothy Akinmurele, Sunday Phillip and the late Usman Yakubu, and Pharm. John Avong, Halima Ibrahim and many others. In the midst of this, we have to still conduct operational and implementation research and publish our findings as previously highlighted. Often, the findings will form the basis for implementation as in the large cohort study previously cited (Charurat et al 2010). We also had to educate and train over 2000 healthcare workers on HIV/AIDS/public health. We shared our experiences in a short chapter entitled: *"Training and Treating at the Same Time: Experiences with National HIV/AIDS Training in Nigeria"* in a Harvard School of Public Health book (Shepherd et al 2009). Currently, we are conducting a similar but more personalized blended e-learning under the aegis of Health[e]Foundation, Amsterdam Institute for Global Health & Development and University of Amsterdam. E-learning will assume more significance in global health in the near future.

There has to be dissemination plan, otherwise your research will remain on the shelves and three people, medical journalists and activists, succinctly brought this to my attention – Samantha Bolton, formerly of BBC, Gombe Spring of Drugs for Neglected Diseases Initiative (DNDi) and Tim Reed, the CEO Health Action International (HAI), Netherlands.

The latter always tells me: "You have to translate your scientific results to the wider world – citizens, practitioners, politicians, policy makers, etc." Lo and behold! That is what they did when Samantha took up a cause we have been bubbling without anyone noticing. After she took it up, the very next week, I saw my humble self, quoted in no less than 12 different newspapers from Los Angeles to Tokyo and many cities in-between. Also, to translate and publicize may mean using other avenues for reaching out like video and online platforms and this is what HAI/Lillian Foundation did with our snakebite programme running on cable networks and online: https://vimeo.com/167436988. My colleagues at Accordia Foundation-Academic Alliance and many academic institutions use podcasts, press releases or even *e-blasts* whenever an important research is published just like they did with our antivenom paper: *http://www.accordiafoundation.org/portal/multiplying-the-impact-across-africa.*

Figure 16: *Different Methods of Resolving Practical Problems (Sichuan Province, China)*

11.0 Conclusion and Recommendations

In conclusion, I would like to reiterate that all the areas covered build into **global health**. It comprises both infectious and non-infectious diseases, stretches from human rights and sociology to mathematics and molecular biology. While some research will remain basic science, most research should be applicable. Medical education and research should have a platform for dissemination, translation, publicity and consequent policy and practice changes, public health intervention and implementation. Where appropriate, research findings should be translated on to an entrepreneurial platform.

In order to pre-empt what the global health challenges will be in the future, we need to predict so that we get prepared. To attempt, it is highly probable non-communicable diseases will or have already become important problems, but no less important emerging and epidemic infections with pandemic potentials and antimicrobial resistance in one guise or the other will threaten humanity. Inequities, vulnerabilities, strife and cross border movement will persist and facilitate transformation into global health challenges. Although populations may shrink even in the developing world, northern Nigeria will probably be among the last to witness substantial decline in populations further promoting inordinately both communicable and non-communicable diseases.

To those in education sector, the need to mount higher training in Global Health cannot be overemphasized. Few Universities in the West have already started, such as Oxford's Masters in Global Health. Bayero University has always been an advocate of "Town and Gown" philosophy and fortunately, the University has all the mechanisms for a global health platform including the College of Health Sciences, Centre for Advanced Medical Research & Training, Centre for Infectious Diseases Research, Centre for Biotechnology Research, Centre for Gender Studies and many other supporting Units. Collaborations within and outside, team work and mentoring for sustainability are necessary to establish an excellent tradition in both global health research and practice. A slight change away from the compartmental model will augur well and these resources will promote the cause of global health for societal good, national and regional health, well-being and development.

To National authorities and policy makers, there is need to strengthen Health systems, Human Resources for Health, surveillance systems, health leadership, prevention and public health, and address health inequities.

To researchers, policy makers especially at international level, there is need to continue to invest in and work on control of HIV/AIDS, Tuberculosis, Malaria, vaccines, emerging infections, epidemics, antimicrobial resistance, unsafe water and improve sanitation. There is need to address/curtail excess salt, excess sugar, and ethanol and tobacco, perhaps through hiking taxes on the latter two. Innovative ways of addressing under-nutrition, unhealthy consumption and other food related maladies should be devised such as the vitamin A fortified sweet potatoes to prevent deficiency.

Meanwhile the dangers of physical inactivity, high blood pressure, metabolic diseases, urbanization, air pollution and climate change should be tackled especially given the growing population in 'transition' in many regions. Social inclusiveness, social justice and interventions to address illnesses arising from inequities relating to gender, human rights and minorities' vulnerabilities should be prioritized e.g,, health of pastoralist, snakebite among rural dwellers or illnesses among impoverished disadvantaged groups, e.t.c. Above all else, illiteracy and poverty should be tackled and health actions intertwined in tandem with socioeconomic interventions. In summary, approaches in medicine and sciences should be used to address these societal health challenges to eventually lead to common public good.

I stop by paraphrasing *Rabbi Hanina* who stated that: 'I have learned much from my teachers but I have learned much more from colleagues and I have learned most of all from my students'.

Thank you, Maasalam and God bless

Acknowledgements

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I will also extend my gratitude to the University management. In particular, the Vice-Chancellor and his principal officers, the Provost, College of Health Sciences, Dean, Faculty of Clinical Sciences, current and past Heads of Department of Medicine, my Unit Head and colleagues. I am also grateful to the CMD and his management at Aminu Kano Teaching Hospital for facilitating our work. Finally, I would like to thank all my colleagues within various boards, committees and societies – the Nigerian Infectious Diseases Society, GSI, NITAG, NDSAC, NAEFI and others. Lastly, I thank the audience for listening, reading and for their patience.

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