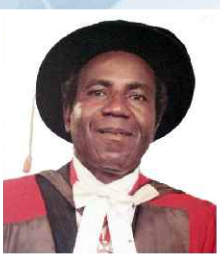


7TH LATE PROF. T.A.I. GRILLO
DISTINGUISHED ALUMNI LECTURE

APOCALYPSE NOW:
A CALL FOR A COORDINATED NATIONAL RESPONSE TO ANTIBIOTIC RESISTANCE

DATE: FRIDAY, 30TH MAY, 2014 TIME: 10:00AM

GUEST LECTURER

PROF. FOLASADE OGUNSOLA

Provost, Medical College, University of Lagos, Nigeria.

APOCALYPSE NOW:
A CALL FOR A COORDINATED NATIONAL RESPONSE TO ANTIBIOTIC RESISTANCE

PROF. FOLASADE TOLULOPE OGUNSOLA

MBChB, PhD, FMCPath, FWACP

LECTURE DELIVERED AT THE

7TH PROF. T. ADESANYA IGE GRILLO MEMORIAL LECTURE

of the

College of Health Sciences
Obafemi Awolowo University,

ON **30THMAY 2014**

at the

Oduduwa Hall, Obafemi Awolowo University,
Ile-Ife, Nigeria

The Vice-Chancellor,
Principal Officers of the University
The Provost College of Health Sciences
The Chief Medical Director OAUTHC
Deans and Heads of Departments here present,
My teachers
Distinguished Scholars and Professors,
My Lords Spiritual and Temporal,
My Professional and Academic colleagues,
Gentlemen of the fourth estate
Students
Distinguished Ladies and Gentlemen

I feel very honoured and privileged to be here in Oduduwa Hallgiving this lecture 32years after I left this beautiful campus. This is certainly not something I ever foresaw.It is really great to come back to the most beautiful university in Nigeria. When the Provost invited me to give the 7th annual distinguished Grillo lecture I was surprised but the surprise soon gave way to excitement and an overwhelming sense of nostalgia for a very beautiful and memorable period of my life. Studying here in Ife was hard work, fun, impactful and memorable. One of my most enduring memories was the ease with which we could approach our teachers and discuss with them. I remember conversations and discussions with Professors Adeyemo, Makanjuola, Durotoye, Baxter-Grillo, Caxton-Martins, GOA Ladipo, Andy, Morakinyo, Arigbabu, Bajomo, Odesanmi to name a few and the great and often formidable Professor Thomas Adesanya Ige Grillo. Conversations with Professor Grillo were not easy and were often at his instance not ours. Professor Grillo always had a gleam in his eyes and was known for his dry wit, piercing gaze, great intellect and uncomfortable questions about your work because he loved to really stretch you. Discussions with him could be described as an exercise in severe mental gymnastics!! We certainlyavoided these mental gymnastics as much as possible, but he got us!!

He had a great passion for the Faculty of Health Sciences as it was called then and was determined to breed doctors who could think and outthink him! I do

not think he succeededin getting us to outthink him…there can be only one T. Adesanya Ige Grillo!I, however, hope we have not disappointed him. He used to lament, when we got restive during a three-hour class, that he would hate to be our patient because we were likely to become doctors that would leave patients on the operating table so we could go to take our lunch!May his Soul rest in Perfect peace and May his legacy never die.

The Ife program taught us to think holistically. It was also designed to foster team spirit as we shared classes with other members of the Health workforce and so learnt to respect every professional group in the health team many of whom became our personal friends. It taught us to think out of the box and not be afraid to be different. Most importantly it taught us to be the best we could be and give our best to any assignment we were given. It did not accept anything less from us.

After all the hard work, by the time I graduated in 1982 I was sure I was never going to pick up another book and would just do what I had always wanted to do, treat patients. I was even more convinced that I would never have to study microbiology again!!! First of all I did not see what it really had to do with patient care and could not understand how anyone was expected to remember all those tongue twisting names and genealogies like phyla, families etc. Was I wrong? I have been a doctor for 32 years and a clinical Microbiologist for 23 of those years.

This lecture is essentially advocating for action against antibiotic resistance. I hope to convince you all of the threat that antibiotic resistance poses to our collective health and make activists of you all in a fight to preserve this precious commodity and save us from ourselves. I have divided this lecture into 5 parts:

1. Apocalypse now: Thepublic health nightmare of antibiotic resistance
2. The Nigerian situation
3. Current global efforts
4. Operationalising the WHO 2011 call to action
5. Apocalypse now: A need for a national response

1. APOCALYPSE NOW: THE PUBLIC HEALTH NIGHTMARE OF ANTIBIOTIC RESISTANCE

In 1998 Professor Stuart B levy, a professor of molecular biology and microbiology, a professor of medicine and director of the Center for Adaptation Genetics and Drug Resistance at the Tufts University School of Medicine, in his seminal paper 'The Challenge of Antibiotic resistance" wrote

> "*Last year an event doctors had been fearing finally occurred. In three geographically separate patients, an often-deadly bacterium, Staphylococcus aureus, responded poorly to a once reliable antidote--the antibiotic vancomycin. Fortunately, in those patients, the staph microbe remained susceptible to other drugs and was eradicated. But the appearance of S. aureus not readily cleared by vancomycin foreshadows trouble. Worldwide, many strains of S. aureus are already resistant to all antibiotics except vancomycin. Emergence of forms lacking sensitivity to vancomycin signifies that variants untreatable by every known antibiotic are on their way. S. aureus, a major cause of hospital-acquired infections, has thus moved one step closer to becoming an unstoppable killer.*
>
> *The looming threat of incurable S. aureus is just the latest twist in an international public health nightmare: increasing bacterial resistance to many antibiotics that once cured bacterial diseases readily. Ever since antibiotics became widely available in the 1940s, they have been hailed as miracle drugs--magic bullets able to eliminate bacteria without doing much harm to the cells of treated individuals. Yet with each passing decade, bacteria that defy not only single but multiple antibiotics--and therefore are extremely difficult to control--have become increasingly common.*
>
> *What is more, strains of at least three bacterial species capable of causing life-threatening illnesses (Enterococcus faecalis, Mycobacterium tuberculosis and Pseudomonas aeruginosa) already evade every antibiotic in the clinician's armamentarium, a stockpile of more than 100 drugs. In part because of the rise in resistance to antibiotics, the death rates for some communicable diseases (such as tuberculosis) have started to rise again, after having declined in the industrial nations. ……"(1)*

Ladies and gentlemen, that statement was made 16years ago and today we are in the grip of anepidemic because little was done! From all over the world there are reports of microbes that are resistant to every antibiotic known to man. However the emergence of a report of an Escherichia coli secreting an antibiotic hydrolyzing enzyme called NDM-1(New Delhi metalo-betalactamase) coming out of India in 2010 shook the world. (2)What was most significant about this discovery was not only that it was producing an enzyme thatconfers resistance to one of the most potent classes of antibiotics, known as carbapenems,which are the last line drugs for treatment of antibiotic resistant gram negative organisms but that this resistant gene was also present on mobile genetic elements that would facilitate rapid spread between organisms. There was finally an organism that was resistant to all drugs and had the capacity to spread rapidly. Its presence in *E. coli*, which is found in the gut of all mammals, means it can be easily and rapidlytransmitted.

The enzyme has now been found in other organisms (3) and at least one in 10 of theseNDM1-containing strains appear to be pan-resistant, which means that there is no known antibiotic that can treat them. To date, Colistin, an old antibiotic which had fallen into disuse because of its extreme nephrotoxicity, affecting the kidney in about a third of people who use it, is one of the only two drugs that have the potential to cure infections caused by NDM1.(1)

The last scene of this rapidly unfolding nightmare is that very few new antimicrobials are being developed.The situation of antibiotic resistance is so dire that it has been considered a threat to world security. The events that surrounding the discovery and publication of NDM-1 supported this view as itled to a major diplomatic incident between India and the western world resulting in some scientists being declared persona-non-grata in India. Since then this organism has been reported from all over the world and was a major catalyst for the theme for the World Health day, April 7, 2011 tagged "**Antimicrobial resistance: no action today, no cure tomorrow".** This, however, was not the first call to action by the World Health Organisation (WHO). In 2001, the WHO raised an alarm and *released a global strategy to contain antimicrobial resistance. They highlighted antimicrobial overuse and misuse as the most*

common causes of drug resistance. However, the September 11 tragedy diverted world attention from the campaign and it never really took off and we are here today.

So what do we mean by antibiotic resistance and what are the pharmaceutical companies doing? What drives this resistance problem? Do we have the problem in Nigeria? and what can we, as a nation, do to stop it? My topic, "Apocalypse now! A call for a coordinated national response to antibiotic resistance", will remind us of where we are coming from concerning antibiotic use, where we are and how we should proceed to ensure that we canprotect this valuable resource and continue to effectively tackle infectious diseases.To do this I will remind us a little about our main adversaries: the bacteria and viruses

Bacteria are everywhere

Of the one thousand million microbes that exist, only 538 bacteria, 317 fungi, 287 worms, 208 viruses and 57 parasitic worms have been shown to cause infections!(4) These organisms that cause infections are called Pathogens and have been the villains of infectious diseases for centuries.Bacteria represent micro-engineering at its finest. They are between 2-4μm in diameter or length.(5)They have two basic shapes: circular (cocci) or rods (baccilli). The circular forms may be in different configurations: diplococcic (two cocci), tetrads (4 cocci), in chains (streptococci) or in bunches like grapes (staphylococci). The bacilli may be curved (vibrio) or spiral (spirillae or spirochaetes). They contain a DNA that is over 1mm long but fits into this tiny cavity only because it is supercoiled. They have all they need to reproduce, respire and survive. Most of them are independent living and are extremely adaptive to their environment. This ability to adapt is aided by and is also a function of their rapid rate of reproduction.

Microbes are everywhere, air, soil, in the sea, on every surface including the human body. The human body is covered completely on the inside (on mucous membranes) and on the outside (on skin) by microbial life with more microbes on our body than there are humans on Earth. There are more than 600,000 bacteria living per square inch of skin with an average person carrying about a quarter of a pound of bacteria at any given time. Microbial cells outnumber all

the cells in our body by a factor of 10 to one. (6)Some of these are permanent residents and we call them the normal flora.(7)Not all bacteria are bad, many are in fact good for us and live in a symbiotic relationship with us and even more importantly our good health is dependent on their presence in the gut. More recently the human genome project showedthat we are "part bacteria" because of the presence of 233 proteins in man with homologues only in bacteria, suggesting that we acquired these genes from our bacteria (8)Thenormal flora is extremely important in maintaining health, they help to prime the immune system, prevent pathogens (disease causing bacteria) from being able to attach and produce chemicals that inhibit or kill other bacteria. (9-11). We therefore cannot and must not try to eliminate all bacteria as we cannot survive optimally in a sterile world.

In 1939 we discovered penicillin and by 1945 it was available commercially. In the two decades,1945 till 1962, following this discovery, there was a flurry of activity as we discovered one antibiotic after the other: -lactams, chloramphenicol, macrolides, tetracyclines aminoglycosides, glycopeptides, quinolones and streptogramins - 9 different classes of antibiotics- all attacking bacteria through essentially four mechanisms: Cell wall inhibition, Inhibition of protein synthesis, Nucleic acid inhibition and cell membrane inhibition. This was going on in parallel with improved public health infrastructure that reduced transmission of infectious diseases, including safe water, good sanitation, improved food preparation, good housing, better access to food and health care. This combination of antibiotics and good public health so led to drastic reductions in mortality and morbidity rates resulting from infectious diseases, that we believed we had conquered infectious diseases. Funding for research and development into anti-infective drugs slowed down and major Pharmaceutical industries turned their attention elsewhere. The profits from antibiotics were nothing compared to profits from drugs for hypertension, diabetes, cholesterol, that are lifelong diseases. Research and development into new classes of antibiotics took a back seat and over the three decades between 1970 and 2000 only two new classes of antibiotics became available. (12, 13)

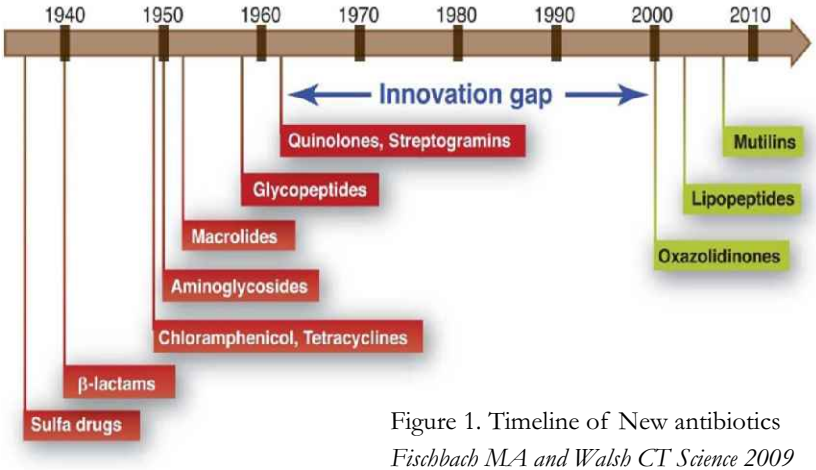


Figure 1. Timeline of New antibiotics
Fischbach MA and Walsh CT Science 2009

However we were wrong.In 1978, there were reports from South Africa of *Streptococus pneumonia* (the bacteria that causes pneumonia and which we treated with penicillin)that was no longer responding to penicillin. That was not all, the organism was also not responding to other antibiotics such as erythromycin andtetracycline which were alternatives. It was multidrug resistant but we called it penicillin resistant pneumonia. (14). By the mid90s the sporadic reports of antibiotic resistance had turned into a ground swell of reports of resistance from all over the world. Both gram-positive and gram-negative strains were involved as well as some killer strains like tuberculosis. Approximately 70 per cent of known bacteria have developed resistance to one or more antibiotics, threatening a return to the pre-antibiotic era. Resistance has been reported for entire classes of antibiotics, and untreatable multi-drug resistant bacteria are increasingly documented.(15) Antibiotic drug resistance is an increasing threat to global health security, potentially compromising gains made in public health worldwide and presently considered to be one of the greatest threat to health. (16-17)

Definition of antibiotic resistance

Antibiotic resistance can be defined as the ability of bacteria and other

microorganisms to resist the effect of an antibiotic to which they were once sensitive. When an antibiotic has lost its ability to effectively control or kill microorganisms at normal therapeutic concentrations, the organism continues to multiply in the presence of the drug

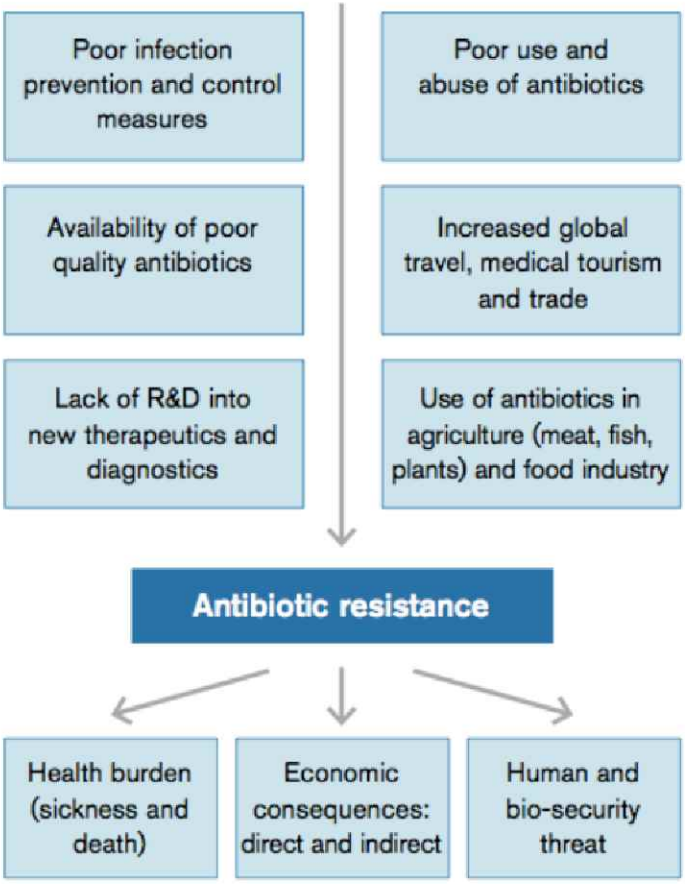


Figure 2: The drivers and consequences of antibacterial resistance (25)

Acquisition and Mechanisms of resistance

Microbes resist antibiotics in a number of ways; by preventing entry into the cell, by producing chemicals (enzymes) that destroy the antibiotic, by acquiring intracellular pumps which pump out the antibiotic as soon as it enters the cell (efflux system) and by changing the configuration of receptors to which the antibiotics attach to the bacterium to effect their action(5)

These changes are expressions of changes that have occurred at the genetic level and may occur due to errors during division of the bacterial genome itself (chromosomal) or by the acquisition of foreign genes which may be from the environment (transformation), or through infecting viruses (bacteriophages) that transfer genes from bacterium to bacterium or by direct transfer from one bacterium to another through a sex tube or pilus; a process known as conjugation. (5) These kinds of exchange occur particularly in the colon (the large intestine) where there are about 10^8 (100,000,000) organisms per gram of faeces. (11) The kind of foreign genes that can be acquired differs but what is consistent is that they are all on mobile elements, which include, plasmids, transposons (jumping genes), insertional sequences and integrons. (5)Integrons are specialized transposons, which are like flypaper and can attract and trap multiple antibiotic resistant genes and disseminate in one fell swoop. Unfortunately, integrons are widespread in bacteria including our gut flora

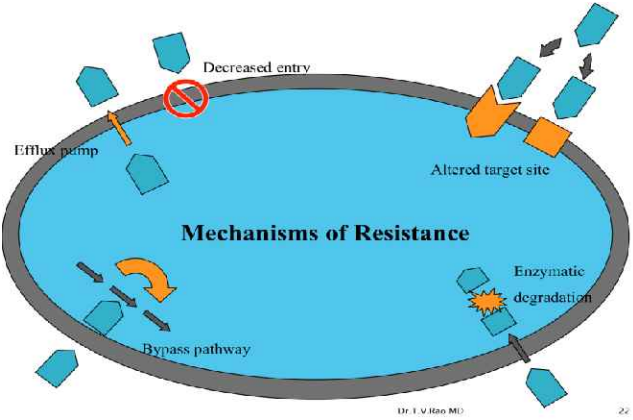


Figure 3: Mechanisms of Antibiotic Resistance.

Most bacteria of medical importance double their population every 20-30mins.[2](5) Bacteria multiply by binary fission with one mother cell giving rise to two daughter cells and two cells to four cells and in 7 hours one bacterium would have given rise to over 4million bacteria and the population would have doubled 20 times!! So once the new gene is acquired or the mutation occurs that makes an organism resistant to an antibiotic, the presence of the antibiotic kills all the microbes against which it is effective leaving behind the resistant strains which soon multiply and become the dominant strain:what we refer to as 'Antibiotic selection pressure'.

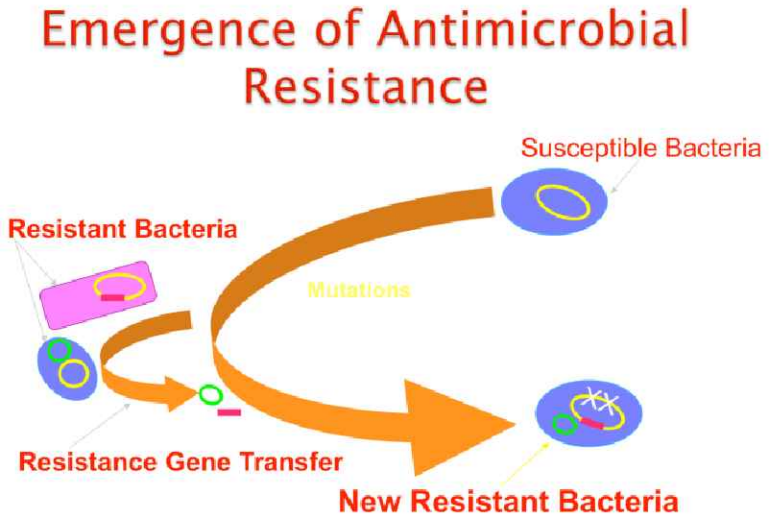
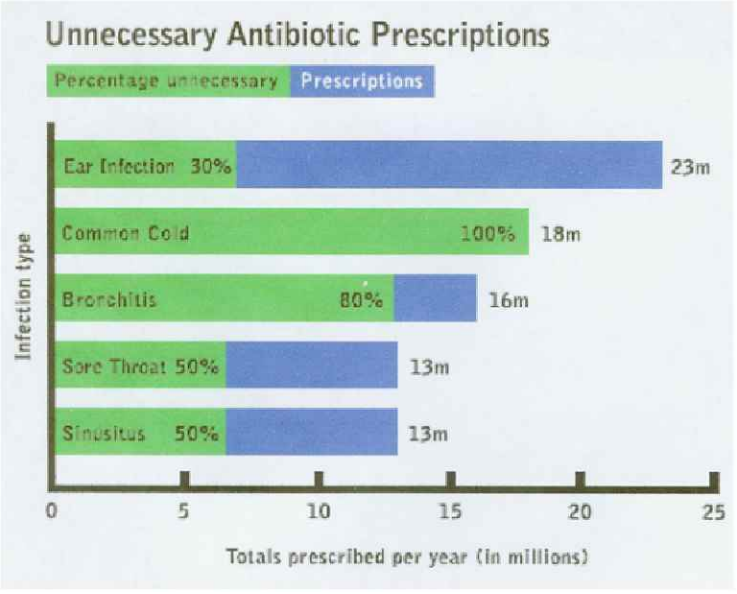


Figure 4 Genetic basis of resistance

How resistance is acquired and spread

Antibiotic resistance has been linked to overuse of antibiotics such as over-prescription of and easy access to antibiotics, antibiotic use in animals, use of antibiotics for non-bacterial diseases, inadequate doses, adulterated drugs and to the fact that most "new antibiotics " since 1962 are modifications of existing

ones. (13,18). Overuse of antibiotics is a global problem, for example, in the United States of America alone, over 50million unnecessary prescriptions are written every year for infections that are caused mainly by viruses or that will resolve without antibiotics. (19)The resistance problem has been estimated to cost the US health care system between $21billion and $34 billion each year. (20)The nature of antibiotic resistance is to grow because it is a survival strategy for microbes. As I had indicated, when antibiotics are used against any organism it will kill off all sensitive strains leaving behind all the variants that are resistant to it. Once the sensitive strains have been killed off, the resistant strains rapidly multiply and soon become the predominant strains



Durnham E. NPR Adapted from Center for Disease Control (19)

Figure 5: Number and type of unnecessary prescriptions annually in the USA

There are only two primary ingredients for spreadof resistance and theseare the presence of resistance genes (allow the bacterium to develop resistance mechanisms)and the extent of antibiotic use (which allow for these resistant genes to thrive and multiply by creating a selection pressure).A third ingredient, though of a secondary nature, are the factors that aid their transmission in the environment such as poor toilet facilities, poor water supply and inadequate hand washing.

In a seminal study by Levy in 1976, he showed that even low dose antibiotics in animals can lead to widespread presence of resistance genes in a community.(21)They introduced antibiotic-laced feed on a farm where they had 300 chickens that were hatched from eggs laid from pathogen-free hens. They separated them into two groups. One group received low dose antibiotic-laced feed (tetracycline) and the other did not. The findings were striking. Within 48 hours, thechickens given the tetracycline-laced feed began to excrete tetracycline-resistant *E. coli*, a commonbacterium in the feces of chickens, people and other mammals. The control group did not. Within a week, almost all *E. coli* in the intestinal tracts of the antibiotic-treated chickens were tetracycline-resistant. Within 3 months of constant feeding with antibiotic-laced feeds the chickens were excreting multidrug resistant *E. coli,* resistant not only to tetracycline, but also to sulfonamides, ampicillin, streptomycin and carbenicillin. This was not all; even the family members living on that farm were excreting an increasing number of multidrug resistant fecal *E. coli.*

This study demonstrated three things; first, that low-dose non-therapeutic amounts of antibiotics canselect for, and help spread bacteria resistant to the drugs at high levels; second, that it can also select for resistance to other antibiotics not being taken; and third, that antibiotic resistance genes can be transferred to those not taking the antibiotic but are in the environment of those so doing, in this case it was from the animals to humans.Most importantly this study demonstrated the ecologic and environmental impact of antibiotics.Antibiotics are the only drugs which when given to an individual affect others as well!! In other words, my resistance is your resistance!! We can

understand this by the sheer numbers of bacteria everywhere with a great propensity to share genetic material such that they behave as though they were one giant creature: you affect one, you affect all.

Various studies have shown the transmissibility of resistance genes. In 2008, another study showed conclusively that previous antibiotic use was a significant factor for carrying Multidrug resistant Staphylococcus aureus called Methicillin resistant Staph aureus (MRSA).In a metaanalytical study whichsearched the important medical databases for all good studiescarried out over a 30 year period (1976 to2007) on the role of antibiotics as a risk factor for MRSA isolation in adult patients. They found that the risk of acquiring MRSA was almost doubled in patients who had taken antibiotics (22)

The communality and environmental spread of bacteria was also demonstrated in another study which showed that those ill with disease are not often the main reservoir for resistance genes but the many others that are carriers. In a hospital in North Virginia USA an outbreak of MRSA in their neonatal ward had remained uncontrollable for 2.5years despite isolation of all sick children and other measures. Between 1977 and 1980, MRSA rates in Pneumonia rose from 0% to24% ,blood stream infections rose from 0% to 40% and surgical site infections from 0% to 49%. New measures were introduced in 1980. All patients were screened for MRSA and contact precautions were instituted for all colonized patients whether they were ill or not. Within 1.5years MRSA had been eradicated, and for the next 10years no cases of MRSA were detected in any patient or staff in that hospital. The success was due to the staff dealing not only with the sick, but identifying all those that had become contaminated by resistant organisms. (23)What this clearly demonstrates is that the human flora is in dynamic equilibrium with the environment. Adult skin sqaumes carry 4 to 10 viable bacteria each and the adult human sheds about 6,000 to 32,000 bacteria per minute. Therefore, anyone carrying antibiotic resistant strains will be constantly contaminating the environment. This needs to be addressed in any solution proffered for combatting antibiotic resistance.

What are the consequences of resistance?

The impact of antibiotic resistance is not just on human health but it also hassocial and economic consequences. Resistance has a negative impact on clinical outcomes with increased mortality and morbidity.The increased morbidity leads to increased human suffering as well as loss of productivity (24, 25). It also leads to increased costs of diagnosis and use of more expensive and often more toxic drugs thathave a higher chance of side effects.At global and national levels, there is real fear that antibiotic resistancewill reverse or at best slow down individual country's ability to achieve some of its Millennium Development Goals.

2. THE SITUATION IN NIGERIA

Nigeria, after 53 years of independence, still has a high infectious disease burden (26) which has been attributed in part to our poor health infrastructure. There is also high rate of antibiotic resistance which is facilitated by the easy access to antibiotics. Antibiotics are too freely available in Nigeria and everyone is prescribing them for everything. Doctors will prescribe antibiotics for any upper respiratory tract infections (URTI) that is associated with production of yellow mucous, diarrhea and fever that does not respond to an antimalarial drug(the so-called malaria/typhoid diagnosis!). We seem not to have a place for viral infections in our differential diagnosis.

Across the country between 33% and 100% of patients will take antibiotics without prescription (27-29). The situation is not better in the hospitals where high rates of antibiotic prescriptions are given. Doctors prescribe at least one antibiotic in 50%-83% of patient encounters (27,30-32).Indications for antibiotics have been largely inappropriate with 25% of antibiotics prescribed for malaria, 22% for respiratory tract infections and 6.1% for typhoid,(29,30) even for menstrual pain. (29). The most common drugs prescribed are Cephalosporins, Penicillins, Quinolones and macrolides.This high rate of antibiotic consumption combined with the ease with which antibiotics can be purchased without prescription is compounded by the use of antibiotics in animal husbandry.

In Nigeria, combinations of antibiotics like erythromycin, tetracycline and

neomycin as well as veterinary equivalents of the quinolones and aminoglycosides are used often in in sub-therapeutic doses as growth promoters in the poultry industry. (33)Antibiotic residues for penicillins, tetracyclines, streptomycin and erythromycin have been recovered from meat from livestock and poultry with heavy concentrations found in the liver and other internal organs. (34-36) Furthermore in 2007, up to $75million was spent annually on about 40million commercial layers from birth to end of their egg laying period to prevent infection. (33)

The earliest reports on antibiotic resistance in Nigeria came in the 1970s and between the 1980s and 1990s there were reports from all over the country of antimicrobial resistant strains. (37,38) At least 30% of all the common pathogens *Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae a*nd *pseudomonas aeruginoasa* were already resistant to the common antibiotics such as penicillin, cotrimoxazole, cloxacillin, and gentamicin(37,39-42). For example, between 1994 and 2007, the percentage of Multidrug resistant *Pseudomonas aeruginosa,* an opportunistic gram negative bacterium responsible for bloodstream infections, urinary tract and wound infections rose from below 10% in 1994 to over 60% at the Lagos University Teaching Hospital (LUTH) (43,44). Today we have reports of resistant multidrug resistant organisms from all over the country. However the figures we have are not comparable. The methodologies are not standardized, with different studies using different parameters. Most of the studies are small and hospital based. There is an urgent need for comprehensivenational data.

Antibiotic Resistance profiles in Lagos in 1980s and 1990s

1. >90% of *Staph aureus, E.coli, P.mirabilis* are penicillin resistant
2. >30% of *K. pneumoniae, E. coli Ps. aeruginosa* are resistant to Ceftazidime , ceftriaxone
3. >30% *Strept pneumoniae* are penicillin resistant
4. >70% of *E.coli* and 40% of *Staph aureus* resistant to co-trimoxazole
5. 25% of *Staph aureus* resistant to Cloxacillin
6. 50% of *Staph aureus* and 37% of *E.coli* are resistant to gentamicin

Eke et al 1987; Rotimi et al, 1987; Odugbemi et al. 1994; Onile et al 1995, Ogunsola et al 1997;

Figure 6: Antibiotic profiles in 1980s-1990

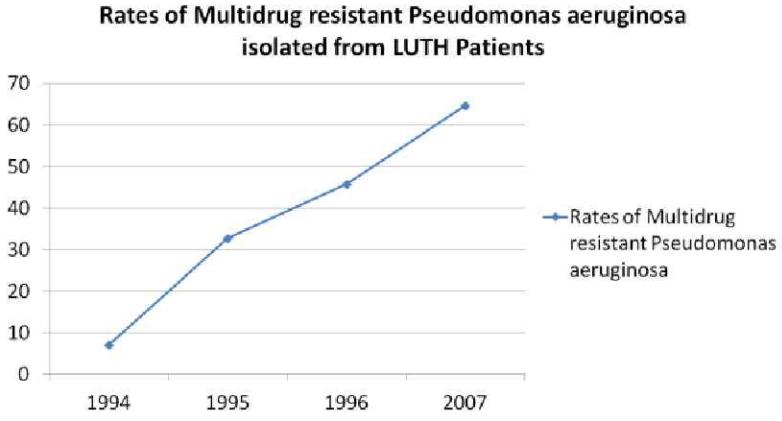


Figure 7: Adapted from Oduyebo, Ogunsola Odugbemi 1997, Aibinu et al 2007

The factors that drive resistance are complex and can be attributed in part to our weak health infrastructure and regulatory mechanisms. The Nigerian health system is fractured into two separate systems: the public "underfunded" "free" health care system and the fee paying private health care system. These two systems are notconstitutionally integrated so that their interaction is notoptimized. There has been very little change in the health sector in terms of real strategic direction in the last 50 years. The main strategic directions have been the introduction of primary health care and the National health Insurance scheme (NHIS), but these have been characterized by poor implementation worsened by the rivalry between the various tiers of government. Poor funding for health, Inadequate number of healthcare workers, poor enforcement of antimicrobial importation, storage and sale laws, quackery and poor regulation of antibiotic use in animal husbandry and agriculture are also contributory factors.(33,36,45,) As occurs inmany other developing countries, many of us have also encountered the itinerant drug peddler on the street, markets or bus, selling cocktails of antibiotics and promising cure of every ailment under the sky!!! We do know that they contribute to the rising antibiotic resistant rates but the degree of their contribution still needs to be quantified.

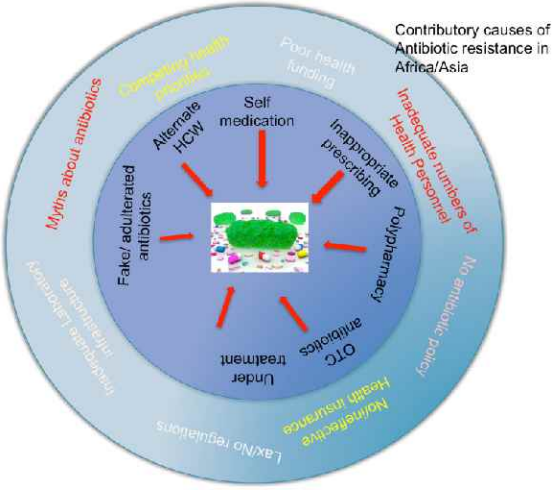


Figure 8: Contributory causes of resistance

Furthermore, the exploding population growth in the cities, attributable to rural-urban spread and relatively high reproductive rates have led to developments of numerous slums where people live in close proximity, which is the kind of environment that facilitate the spread of microorganisms and thus infectious disease (as well as multidrug resistant organisms).The high rates of transmission that are more prevalent where humans live in close proximity will therefore further exacerbate the epidemic. African communities are growing rapidly and it has been predicted that by 2050, the population in Africa will hit 2 billion and 60% of these will be living in the cities, mostly in slums. Closer to home, Lagos is predicted to double its population in the next 10years by 2024.(46)

These have led directly and indirectly to a health workforce that is generally demoralized, overworked, and overpoliticised (riddled with inter and intraprofessional rivalry).The health work place is also badly affected with Hospital managers struggling to get enough funding to maintain minimum environmental hygiene standards in hospitals with aging, dilapidated infrastructure and inadequate diagnostic facilities.All these contribute to inadequate patient safety and poor patient experience. There is therefore a widespread public perception that hospitals are places of last resort. Patients will goto public clinics/hospitals only if they have to. They would have been to the brother, friend, neighbor, church, chemist, traditional healer before going to see a doctor. This occurs at all the tiers of healthcare. Worse still, these patientswould have been prescribed antibiotics, mostly inappropriately, at every point. The looming threat of antibiotic resistance will add a greater burden on the health system. Unfortunately, as in many developing nations, the geographical spread, health and economic burden imposed on the health system is difficult to quantify because the surveillance evidence is just not available.This sorry state of the health sector was well captured in a recent social commentary I read on the Internet:

> "*In the 2013 budget, as presented to the National Assembly, a sum of N279.23Bn was allocated to the health sector,representing 6.04% of the total nudget. This is a far cry from the 15% recommended by the World*

Health Organization (WHO) and the agreement signed by several African heads-of-state in 2001 (of which Nigeria is a signatory) to budget a minimum of 15% to the health sector due to the problem the sector is facing and its importance to the well being of the populace. The 2013 budget incorporates tax reliefs / incentives / concessions for some sectors, chief of which are: Aviation sector, Mineral sector and Transport sectors. Commendable step you would say until you take a peep at the Health Budget.

It is curious that the health sector, riddled with the prevalence of fake and substandard drugs / inadequate medical equipment and dearth of quality personnel was not given a look-in! How do we, in clear and simple terms, show our dedication to quality healthcare if, with our very low budget allocation to the health sector, we still didn't provide incentives / concessions that would help that sector grow?
The sad part is that majority of our people don't have any trust in government health centers, save a few good ones, because of the state of their infrastructure, attitude of staff and inadequacy of the solution they offer. Still most don't have a choice! Who can blame them?

The people who allocated this ridiculous amount are those who run abroad when they experience the slightest symptom of discomfort like sneezing. Shouldn't we claim entitlement to the quality of the same things they enjoy? Are we second-class citizens, who don0t deserve quality health? A country that boasts of 25 doctors per every 100,000 population (using 39,210 doctors for 158 million people) has made doctors out of us all. Tell an average Nigerian you have headache, a running stomach, cold or cough; he/she will outline what to use, how to use it and the frequency of usage. In some of these cases, the victim runs to a chemist, buys the drugs (fake, substandard, expired or good ones, they have no way of telling) and proceed as explained by the street "doctors"."(47)

The foregoing encapsulates the challenges facing the health sector. In spite of this, the health sector must be at the heart of the national response if it must be meaningful. On the 19th of February 2014, the Nigerian Senate passed the National Health Bill 2014, which is an act to provide 'A Framework for the

Regulation, Development and Management of a National Health System and set Standards for Rendering Health Services in the Federation.' It is expected to provide the much needed backbone for reforms in the health sector. It must work!'Doing nothing' is not an option. A glimpse into a future with no antibiotics is like looking back into history, to the days when infectious diseases were death sentences; to the era of large pandemics of bacterial infections such as the plague which took millions of lives; to a time when havingpulmonary tuberculosis or leprosy meant banishment from towns and incarceration insanatoria till death!Maternal mortality rates will start to climb again because infections with multidrug resistant organisms will mean incurable puerperal sepsis.Mortality rates will rise in patients on steroids, those with HIV, Sickle cell anaemia, diabetes, malignancy and trauma that come down with infections. Even the previously healthy can be smitten with incurable pneumonia sepsis from minor injuries. We must not allow a return to the pre-antibiotic days, a world without effective antibiotics.

3. CURRENT GLOBAL EFFORTS TO REVERSE ANTIBIOTIC RESISTANCE

The World Health Organisation (WHO)has taken the lead on driving the global response to antibiotic resistance. The calls by WHOin the last decade have risen incrementally in their urgency. In 1998 the World Health Assembly of the World Health Organization (WHO) urged member states to develop suitable measures to tackle antimicrobial resistance.(48) In 2000, WHO called the rise of antimicrobial resistance (AMR) a global crisis, and in 2001 it released its first global strategy for its containment.(49) In 2011,WHO came out with a 6-component policy statement that would allow countries to adequately combat antibioticresistance.(50) Other countries and associations have also come up with policies and guidelines aimed at resolving the problem. These include The Alliance for the Prudent Use of Antibiotics (APUA)(51) which is engaged in research, surveillance, advocacy and education; Re-Act (Action on Antibiotic Resistance), an independent global network, which aims to promote awareness and action; (52) WAAR (World Alliance against Antimicrobial Resistance) an independent global network of healthcare professionals politicians and patient

groups committed to advocacy and action which in 2012 came out with the "Barcelona declaration" (action to combat antibiotic resistance in Intensive care units) (53,54) and the Infectious Disease Society of America(IDSA)which has championed the need for new antibiotic therapies ('Bad Bugs, No Drugs 10 by 20' initiative to support the development of ten new antibiotics by 2020). (55)

More recently Indian medical societies came together against antibiotic resistance and came up with a roadmap to combat antibiotic resistance in India, "The Chennai declaration", that was tailored to their local circumstances (56). Yet, despite all of the global meetings and recommendations and the overall consensus that global coordination of efforts is paramount for tackling the problem there is still no truly international action (25) because the policy makers are not yet on board.

4. OPERATIONALIZING THE WHO 2011 CALL TO ACTION

The drivers of antibiotic resistance are complex and multifactorial so the solution must be multisectorial with roles and responsibilities for everyone. It has been demonstrated clearly that the combination of an effective antibiotic stewardship with acomprehensive infection control program in the hospital environment has been shown to limit the emergence and transmission of antibiotic-resistant bacteria. At the level of the individual it requires behavior change but the individual change can only occur where there is political commitment, teamwork and funding.The solution must therefore address antibiotic use, bacterial transmission as well as find ways to restore environmental bacteria that are generally susceptible to antibiotics. WHO's6-component policyprovides the frameworkto achieve all these. The drawback, however, is that the policy is very broad and addresses many issues without attaching any weights to them. Each country will therefore have to prioritize the importance of each component relative to their activities and their identified gaps. Most of the activities required to reverse the current trend in resistance rates will occur at the level of the individual hospital, farm or home but the coordination and strategic direction for the country and institutions must come from Federal Governmentso that the national response is cohesive and sustained.

The WHO six-component policy statement requires each country to:

1. Commit to a comprehensive, financed national plan with accountability and civil society engagement
2. Strengthen surveillance and laboratory capacity
3. Ensure uninterrupted access to essential medicines of assured quality
4. Regulate and promote rational use of medicines, including in animal husbandry, and ensure proper patient care
5. Enhance infection prevention and control (IPC)
6. Foster innovations and research & development for new tools

These six components essentially promote activities that will:

A. Protect the antibiotics we already have by reducing the rate of generation of resistance genes (antibiotics stewardship);
B. Reduce the spread of resistance genes in the environment(infection control);
C. Lead to an Increase in the number of new antibiotics in the production pipelineas well as the development of other tools for diagnosis, treatment and prevention of infections.

A. P**rotecting the antibiotics we already have. (Antibiotic Stewardship)**

WHO defines stewardship as 'the careful and responsible management of the well-being of the population' (57).The role of a stewardship programme is to balance the benefits of antibiotics for health against the need to minimize improper use and reduce use overall.

I. Set up Antimicrobial Stewardship programmes in hospitals

Antibiotic stewardship programmes must be set up in all healthcare institutions primary, secondary and tertiary facilities. These programmes will be run by teams or by an interested health official in smaller facilities. **The ultimate goal is to optimise patient outcomes, while avoiding an increase in the number of antibiotic-resistant organisms encountered over time.** The working goal, however, is to administer an appropriate antibiotic of sufficient dose and duration to eradicate pathogens and to prevent recurrence of

infection. If an appropriate antibiotic is administered, but is of insufficient dose or inappropriate duration it results in the selection of pathogenic organisms that are not sensitive and resistance can develop. Issues of antibiotic prescriptions, dosage and duration of antibiotics and empiricism need to be addressed, and treatment and prophylactic guidelines developed.

Special attention needs to be paid to primary care providers in both public primary care centres as well as private clinics. In most countries, primary care still accounts for the majority of antibiotic use, where poor prescribing is directly implicated in the development of resistant bacteria. (58) Poor prescribing can be attributed to lack of knowledge, poor diagnosis, patient pressure and financial motivations on the part of the prescriber. Many countries have been successful in reducing primary-care prescribing, but such efforts require close attention to local economic incentives. For instance, France's 200207 National Action plan produced a 23 per cent reduction in antibiotic consumption through surveillance, public-awareness campaigns, education for health professionals and rapid testing for certain infections (59).

The consumption of antibiotics needs to be monitored prospectively and retrospectively in order to ensuretheir appropriate use and to reduce the unnecessary exposure of organisms to these agents. It is proposed that each hospital adopts antibiotic interventions for acute treatment and surgical prophylaxis. The number of interventions introduced and number of people may depend on a variety of factors and should be tailored to the particular circumstances within each hospital. This requires the commitment of the leadership of the hospitalas this has to be funded and supported.

To start off, each health care facility will need to collect data to identify their problems, (the infection rates in the facility and specific units, identify units with a high occurrence of resistant organisms, determine current antibiotic prescribing behaviour and identify areas of inappropriate antibiotic usage.) The type and size of the hospital and the patients' profiles will influence the interventions to be considered. The key opinion leaders as well as major role-playersin each facility must be identified. These should includeall doctors

admitting or treating patients in the hospital, Microbiologists who can be consulted regarding organism profiles and make recommendations regarding antibiotic prescribing, Pharmacists who can monitor antibiotic prescribing and usage and provide feedback to doctors, nursing staff as well as patients. An Infection Prevention Control (IPC) Practitioner or team undertaking active surveillance, monitoring adherence to IPC principles and providing feedback to the facilityis an invaluable asset that should be identified and encouraged. Having an effective stewardship programme requires a consultative-type of leadership so that all stakeholders are aware of and well educated on the problems of antibiotic resistance.

II. Education of Health Care Workers.
Education is extremely important and must be targeted at healthcare professionals at all tiers of healthcare including general practice.The training needs of all major role players,Physicians, Pharmacists, Nurses and others considered relevant, must be identified and appropriate training facilitated to enhance their knowledge and equip them with the necessary tools to be effective.The training must be designed to teach the core principles that will encourage change in behavior concerning antibiotic use.The trainingmust promote the use of reasonable evidence-based prescribing guidelines for empiric therapy as well as the importance of taking specimens for culture before prescribing antibiotics at all levels.

Education on appropriate and responsible antibiotics use must also be a part of the undergraduate and postgraduate curriculum of all healthcare workers. It must also be part of the general education studies of all undergraduates in the first two years in university.

III. Education of the Public This should be undertaken by civil society organisations, professional associations as well as by clinics, hospitals and the Ministry of Health using multimedia approach, includingradio, television, posters and other IEC (information, education and communication) materials. Social media such as twitter and facebook should also be used to target the younger members of society. There is also the need to engage in large public

awareness campaigns. The message should raise awareness of the issue of antibiotic resistance and consequences of the loss of this powerful resource as well as seek to dispel the myth of antibiotics being powerful. The message should encourage responsible antibiotic use such as completingprescribed doses andconsultingdoctors for diagnosis and prescriptions and discouraging antibiotic sharing. The use of antibiotics for diarrhoea, common cold and the use of antibiotics without a doctor's prescription must also be strongly discouraged.

There should also be public education on hand washing, cough etiquette and good hygiene practices. Knowledge of appropriate antibiotic use can dramatically reduce abuse, especially in the absence of contrary financial incentives.(60) In Thailand, a multifaceted response as part of an Antibiotic Smart Use programme used patient education measures, along with treatment guidelines, to reduce antibiotic use by 1846 per cent.(61).Messages should also be targeted at young children in schools, both in primary and secondary schools. This should not only be incorporated into the school curriculum but should be augmented with messages delivered by healthcare professionals and civil service organisations. There is a need to catch them young as it is easier to teach the right habits than try to change wrong behavior in adulthood.

IV. Advocacy: Advocacy should be targeted at getting political commitment of governments, National Assembly,professional associations and management staff of hospitals, clinics and farms.This will need to occur at various levels withinhealth institutions, local, state and federal government topromoteareas where efforts need to be focused, and suggests ways in which a national commitment could be fostered.Getting political commitment is hard so there needs to be lots of advocacy to politicians, Government officials, and regulatory bodies to transmit the urgency of the situation and get their buy-in. To provide the required legislation and regulatory mechanisms will require getting the right message and using the right language. Advertising companies will be needed to sell the message. Advocacy should also promote the need for better **public health measures such as safe water, immunization, infection control, affordable housing and sanitation to reduce infection rates and therefore**

reduce the pressure to use antibiotics.

V. Improve diagnostic abilities: Laboratories play a critical role in disease control and prevention programmes and by extension the diagnosis of antimicrobial drug resistance by providing timely and accurate information for use in patient management and disease surveillance. Both clinical and public healthlaboratories need to be strengthened to provide diagnostic back up for antibiotic resistance. Introduction of point of care tests such as procalcitonin may assist to distinguish bacterial from non-bacterial infections and so reduce unnecessary use of antibiotics.

Laboratories in Nigeria as is the case with many African countries are generally neglected and are therefore inadequate to provide the necessary support needed to combat antibiotic resistance. The World Health Organisation African Region (WHO AFRO), in 2009, in collaboration with the centers for Disease Control and Prevention (CDC), the Clinton Health Access Initiative (CHAI), the American Society for Clinical Pathology (ASCP), and other partners, launched a stepwise laboratory improvement process towards accreditation, in the presence of government health officials from 13 African countries to improve the quality of laboratories. The accreditation process is a five-step approach and laboratories work through a series of prescribed improvements for which they are awarded a star if successful.The laboratories move up the ladder from a one-star to a 5-star laboratory as the quality of their processes improves.(62) A number of laboratories are already involved in the process in Nigeria. However management of health care facilities need to improve funding of laboratory services if we are to have quality heath care and reverse antibiotic resistance.

VI. Reduce antibiotic use in animal husbandry: Globally, more than 50 per cent of antibiotics are used in animal agriculture,(63)and evidence in the last 35 years has suggested a correlation between use in animal husbandry and the spread of associated resistance genes in human pathogens, as well as direct transfer of resistant bacteria from animals to humans.(64) Resistance can be spread by consumption and handling of raw or inadequately cooked food, by cross-contamination or through direct animal contact. The environmental

dispersal of animal manure with high antibiotic content has potential regional and global implications. Some antibiotics are in simultaneous use in food animal and human medicine.

The use of antibiotics in agriculture in Nigeria is still largely unregulated. In Africa, apart from South Africa, there is no strict policy on antibiotic use for food animals There is still a lot of polyvalent antibiotic usein animals often to prevent infection and as empiric therapy.Studies in Kenya and Nigeria found that 82% and 95% of farmers respectively administered drugs without the input of veterinary personnel (36).This appears to be due in part to ignorance as well as poor laboratory back up for veterinary medicine. Farmers' associations need to be a part of the discussions and it is critical, that education messages and advocacy tools should be targeted also at veterinary doctors and those in animal husbandry. Furthermore, in various developing countries such as India, Kenya, South Africa and Vietnam, agricultural use of antibiotics is rising rapidly, as a result of both greater demand for meat and increased availability of antibiotics. One good outcome of the years of advocacy based on the evidence is that use of antibiotic-growth factors have been banned in Europe and the United States of America.(25)

The regulation of antibiotic use in animals must be a priority. The use of antibiotic growth factors in animals needs to be determined. Outright ban may be unenforceable at the present time. Most of the antibiotic used is by individual farmers and not by the veterinary surgeons (the equivalent of self medication in humans!) A first step might be to ban the use of antibiotics in animals that are used for the treatment of human infections.

B. Reduce the spread of antibiotic resistance genes (Infection Control)

I. Setting up Infection control programmes

The Ministry of Health should have a department for infection control. This should ideally be in the division for quality assurance and ethics. It must be linked to the Divisions of Public Health and Hospital Services. All healthcare institutions must also set up infection control programmes ; these programmmes should be well funded. These will require committees to

formulate policies and develop guidelines on hand hygiene, cough etiquette, proper use of disinfectants and sterilization procedures, and proper use of personal protective equipment. In smaller clinics, however, all that may be required is one champion who ensures that basic infection control activities occur. Policies for preventing spread of multidrug resistant organisms and containing outbreaks need to be developed. In addition, these programmes will carry out surveillance on multidrug resistant strains. It is important at the initial stages to identify a few key organisms and gradually scale-up.

II. Public health improvement. Communicable diseases still account for a major part of our morbidity and mortality rates. Safe water, good sanitation and safe housing reduce the transmission of diseases. At the present, antibiotics are being used as a substitute for hygiene. Public health needs to be improved because antibiotics cannot be relied upon to be the primary response to infections. The issuesof poverty and urban slums also need to be addressed as a nation if we are to win the war against communicable diseases and antibiotic resistance.

C. Research and investment in new antimicrobials.Conservation of antibiotics must be carried out in tandem with the production of new antimicrobials. There must be increased government support to basic and applied research relating todrug discovery, new target sites as well as faster and cheaper diagnostic tools. This has already started globally and thereis ongoing research into new chemicals with new target sites as well as novel strategies of delivery that spare the normal flora e.g. bacteriophages, monoclonal antibiotics and antibacterial vaccines. A call has been made by pharmaceutical industries to make the regulatory approval process for antibiotics faster, smoother, cheaper and more predictable because in its present form, it is so cumbersome that it is discouraging investment into this sector. Pharmaceutical industries are also being encouraged to collaborate rather than compete by sharing data so as to fast track research into new antimicrobials. Research into new antimicrobials is very expensive so new funding mechanisms are being explored to incentivize pharmaceutical companies to resume research and development.

5. APOCALYPSE NOW: A NEED FOR A COORDINATED NATIONAL RESPONSE.

Addressing the antibiotic resistance problem needs amulti-sector response. The first component of the WHO action points is that each country must "commit to a comprehensive, financed national plan" Getting political commitment is key. The commonality of bacteria and easy environmental spread means that the steps we take to address the resistance rates must be national in scope. The national response must also key into the regional response as well as the global response.Only government involvement can make this happen. Thus far, the issue of antibiotic stewardship is a buzzword in only some microbiology departments in a few teaching hospitals.

Adequate planning is critical to the establishment of a successful national response. This multi-sector response must be championed by the Ministry of Health and must not be limited to being a health issue. It is also needs to be addressed as an agricultural, environmental, economic and security issue. The country will need to set up a high powered antibiotic advisory committeewith membership drawn from all stakeholders with a mandate to come up with a roadmap for tackling antibiotic resistance in Nigeria. Suggested stakeholders include representatives of the Ministries of Health, Environment and Agriculture and Natural Resources, NAFDAC, WHO, CDC Nigeria, members of academia, civil society organisations, private practitioners, pharmacists, microbiologists, veterinary surgeons, and agriculturists.

Getting policy makers on board requires advocacy and civil service organisations are critical to form pressure groups. Worldwide, the commitment of the policy makers has remained elusive. We must find a way of communicating the problem, using the language they understand that would communicate the sense of urgency required to mobilise for action. We must thereforecarefully plan the communication strategies to create awareness about the global problem of antibiotic resistance and the Nigerian context using in-country data.We must also use the opportunity to introduce the evidence and rationale for the required interventions. Theinitial communication strategy can be in the form of a national workshop on antibiotic resistance that will bring

together all the stakeholders to work out the way forward for Nigeria, very much like the meeting that took place in Chennai India.

There is a lot to learn from the Indian response. The rationale behind the Chennai Declaration, a roadmap for tackling antimicrobial resistance drafted by the medical societies in India in 2012, was to adopta stepwise approach to tackling the problem. For example, in recognition that it is not feasible to control over-the-counter sales of all antibiotics,it produced a list of 24 second- and third-line antibiotics that can be purchased only with a prescription. On the 1st of March this year, the Indian government enacted a lawlisting those drugs as prescription-only and their usage will be monitored. We must also begin the process of engagement with all stakeholders.

I hereby take the liberty of suggesting some actions we should take as a nation.

1. Government should set up a National Advisory Committee for antibiotic resistance and infection prevention and control to provide the overall strategic framework.

2. All healthcare institutions should be mandated to have antibiotic stewardship and Infection control programmes. At the present time, no public hospital in Nigeria has a fully functional infection control programmeor antibiotic stewardship programme. Infection control and antibiotic stewardship are quality standards and require management support and funding to be effective. They, therefore need a champion in each health facility to drive the process. The investment pays off in the long run not just by reducing antibiotic resistance, but also improving patient safety and experience. There will be an initial financial outlay that can be mitigated while sustaining the motivation of hospitals to attain the quality required for international accreditation by adopting a stepwise approach.

We can borrow from the WHO stepwise accreditation process for laboratories already ongoing in the country and apply it to antibiotic stewardship and infection control. The stepwise accreditation process was developed in

response to the poor human, infrastructural and financial resources of laboratories in most countries in Africa. The processes, documentation, equipment and infrastructure needed to achieve world standard accreditation were divided into five (5) modules. Laboratories are given one star for each module passed. Laboratories with 5 stars can then apply for the international accreditation. This same mechanism can be set up for developing functional antibiotic stewardship and infection control programmes. Hospitals can also be incentivized for achievement, for example, by giving a plaque to display as a 5-star hospital, getting tax breaks for being 5-star or extra funding too facilities help them achieve the next star. Setting this system up will require that we partner with the academia, WHO, CDC, and global accreditation agencies who have the expertise. If we can achieve good infection control and antibiotic stewardship programmes in our hospitals there will be a major change in the quality of our healthcare, in fact, I dare say that, we will begin to reverse the present direction of flow of medical tourism.

3. We need a situational analysis of the extent, drivers and socioeconomic impact of antibiotic resistance in Nigeria. It must factor in the agricultural sector. The first situational analysis can be carried out bythe academic sector in partnership with pharmaceutical companies but it should ultimately be driven by government as a function of the public health system and must be a continuous ongoing event.
4. A multi-sector dialogue on antibiotic resistance should be done within the next year. One or a number of associations involved in antibiotic conservation should drive the process
5. Civil society organisations (CSOs) can start the process of public enlightenment and advocacy. Antibiotic resistance concerns everyone and any CSO with a health-related mandate should be involved especially those in HIV, TB, child and maternal health.
6. Government should ban the over-the-counter sale of some high-end antibiotics except by prescription. Such drugs should not be carried nor dispensed by any drug store unless run by pharmacists (not just pharmacist-assisted registered shops)

7. The role of veterinary surgeons in animal husbandry must be strengthened.Antibiotic treatment and prophylaxis guidelines for animals must be drawn up and enforced.

I do not claim to have all the answers. These are suggestions on what I believe we must do as a nation. I do hope that I have improved your understanding of the threat of antibiotic resistance and communicated my sense of urgency that we must act now and not tomorrow. Most importantly, I do hope I have communicated that success is dependent on each one of us by making a pledge today to use antibiotics more responsibly.

Finally, I hope that Professor T. Adesanya Ige Grillo (if he were alive) and all my teachers here present will not be afraid to turn up at our clinics. I assure you we will not leave you on the table and go for lunch!
I thank you all for listening.

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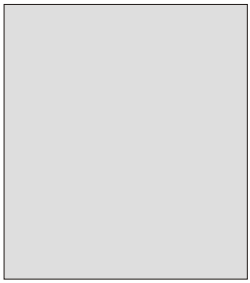

PROF FOLASADE OGUNSOLA

Folasade Tolulope Ogunsola (Nee Mabogunje) is a Professor of Medical Microbiology and Parasitology, and the current Provost of the College of Medicine, University of Lagos. She is a 1982 alumnus of the College of Health Sciences, Obafemi Awolowo University, Ile-Ife, and a Fellow of both the National and the West African Postgraduate Medical College. She has a PhD in Medical Microbiology from the University of Wales, College of Medicine, Cardiff, UK.

She is a committed lecturer, excellent researcher, and an outstanding academic mentor: she has over 70 publications in various notable peer-reviewed local and international journals and has supervised over 50 postgraduate students consisting of MSc, PhD students and resident doctors. She has won research grants from several organisations including USAID, Fogarty International centre of the national institute of Health, USA, and CDC PEPFAR.

Prof Ogunsola is a globally renowned expert who has served in various leading capacities with the World Health Organisations (WHO). She currently serves as the Chairman of the World Health Organisation Working Group on Infection Prevention and Control Curriculum, and is a member of the Global Infection Prevention and Control Network (GIPCN). Her expertise has taken her to various parts of the world as one of the leading infection control experts. For example, she was one of the experts deployed by WHO to address the Ebola outbreak in Uganda in the year 2011 and 2012 and has been serving in the

WHO African Region Rapid Response group of experts for epidemics since 2011. She served as a consultant for developing the Strategic Framework for WHO African Region in 2009. She has served as a consultant to major pharmaceutical organisations on antibiotherapy and antibiotic resistance such as Sanofi Aventis and Astra Zenica. She also serves as a consultant Microbiologist with Pathcare Lagos, a private Laboratory affiliated with Pathcare South Africa.

She is a visionary healthcare professional who is very resourceful, development-focused and passionate about community-level care. With the AIDS Prevention Initiative in Nigeria (APIN) Grant received in the year 2003, Professor Folasade Ogunsola built the Kuramo Clinic with which Primary health care services as well as treatment of HIV and STI were provided to slum dwellers in Lagos from 2003-2006 then 2010 till date. The grant also gave room for the development of a HIV reference laboratory in the Central Research Laboratory of LUTH, College of Medicine in the year 2005. Also, with the FHI grant received in the year 2004, she implemented the development of strand displacement amplification at the Department of Medical Microbiology and Parasitology research laboratory.

She has been instrumental to the development and implementation of policies relating to infection control at institutional and national level. Among others, she has been the Chairman of Infection Control Committee of the Lagos State University Teaching Hospital from 2006 till date, and Chair of the National Tuberculosis Laboratory Working Group from 2009. As a member of the Lagos University Teaching Hospital committee on antibiotic policy for three years, she made remarkable impact on the formulation of policies on the use of antibiotics. She the current auditor of the National Association of Colleges of medicine, and a past member of the Board of the Medical and Dental Council of Nigeria, she currently serves on the Board of the National Psychiatric Hospital, Yaba. She has served on various accreditation teams of the National Postgraduate Medical College of Nigeria since 2000 till date. She was the editor of the Journal of the Nigerian Infection Control Association between the years 1998 and 2006.

Prof Ogunsola is a member of various reputable learned societies and associations including the European Society for Clinical Microbiology and Infectious Diseases, American Society for Microbiology and Infection Control African Network. She is happily married with children and her hobbies include singing classical music. She is a member of the Musical Society of Nigeria pand of the Choir of the Anglican Church of Ascension, Opebi, Lagos.

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