I. 'Role of Public Health professionals and the Community in the Control of Antibiotic Resistance'- Report of a panel discussion

Panelists

Introduction to the theme- (Dr. Mira Shiva)

Over the years medicines have been introduced in community health programs and they have found markets in remote areas, unregulated and unsupervised. While they have saved lives when rationally used they have also resulted in serious adverse affects which have unfortunately remained unmonitored. The adverse affect of irrational use of antibiotics has not only created problems for individual patients but also for the community. Emergence of drug resistance for many of the communicable diseases have been noted. Among the significant ones have been Malaria, T.B., Typhoid etc. Over thousand deaths took place due to emergence of resistance of the common antibiotics against Bacillary Dysentery (Shigella Shega) in Bengal in 1980s which rapidly spread to other areas. Continued sales of combinations of antibiotics were responsible for emergence of drug resistance. Extended Public Interest litigation resulted in banning of some of these e.g. Streptomycin Penicillin combination and also Chloramphenicol Streptomycin combination. **Rational Use of antibiotics is essential to prevent antibiotic resistance as a public health problem.** And for this it is essential to 'know your medicine', antibiotics in this case as well as 'now your body' and 'know your health problems'. Improving health literacy and health awareness has to go side by side with improving awareness about medicines. The cost of antibiotics has definitely contributed to irrational drug use and also emergence of antibiotic resistance. Lack of knowledge about the prevailing health culture and failure to communicate in a patient-friendly manner about health and disease and role of medicines in disease care especially where anti-microbials and living organisms are concerned has resulted in overuse, misuse and under use of medicines. Decreasing immune status of the human body and increasing vulnerability to infection due to poor nutrition, must also be addressed when addressing the issue of emergence of drug resistance.

The Global Challenge- (Prof. Otto Cars)

The growing phenomenon of bacterial resistance, due to use and abuse of antibiotics and the simultaneous decline in research and development of new drugs, is now threatening to take us back to a pre-antibiotic era. Although the essential components of control of antibiotic resistance have been well known for long, there has only been limited success in changing policies and efficiently responding to the problem. However, national campaigns have been initiated in some countries with significant effect on the antibiotic consumption level.
To reach the concerted action on antibiotic resistance, all levels in society need to be involved. In Sweden, a national programme, Strama, was implemented more than 10 years ago and is now integrated in the health system and supported by the Government. Through the County Medical Officers for Communicable Diseases, regional Strama groups are established in every county. Treatment guidelines, feedback to prescribers and patient information leaflets are examples of multiple activities and interventions that are being used to address the irrational use of antibiotics e.g. for viral infections and otitis media. On the national level, the total antibiotic use has been reduced by more than 20%, in children with 40% without measurable negative consequences. Several large diagnosis-prescription studies have been performed both in outpatients and in hospitals. (for further details see paper, section -II following this report)

**Antibiotic Resistance: A view and some lessons from a Community Hospital.** (Dr. Anurag Bhargav)

A review of data and perspectives from the frontline of healthcare, from a program in rural Chattisgarh which included primary and secondary care facilities and which cater to the poor and the underserved, in one of India's rural areas, shows a situation which is both alarming and unexpected. This situation includes drug resistance on isolates from urinary tract infections, tuberculosis, and falciparum malaria and has serious implications for treatment and control of communicable diseases, both at individual and programmatic level.

Such data is usually under-represented in academic and policy discussions. The crisis of drug resistance should be placed always within the context of the larger crises of public health and healthcare in India. A response to this problem requires a major shift away from a fragmented, germ and disease centered approach. There is a pressing need for attention to the foundations of public health, for strengthening of primary care, for education and regulation in the prudent use of antibiotics, for infection control measures in healthcare settings, if this public health disaster is to be addressed with any efficacy. (for further details see short paper, section –III following this report)

**Information and Interaction – Influencing Provider and Consumer Antibiotic Behavior** (Prof. Cecilia Stalsby Lundborg)

Antibiotics are life-saving and commonly used drugs. Antibiotic use is probably the most important factor in resistance development. It is of outmost importance that antibiotics are accessible and used when needed, but used as little unnecessarily as possible for reasons of resistance development, adverse drug reactions and costs. Influencing provider and consumer behavior in relation to antibiotic use is a complex process involving knowledge, but which also involves a number of other factors such as attitudes, social norms, socioeconomic conditions, peer pressure, experiences etc. When designing projects or programs for change it is often useful to consider theories or models of behavior change. For professionals Schöns’ model, emphasizing “knowledge in action” and “surprise” as important drivers for professional change is useful. The “Stages of change model”, including the stages; pre-contemplation, contemplation, preparation, action and maintenance has been used in contexts of influencing professionals and lay-
people. People in different stages of change are susceptible to different intervention strategies. Further, concepts are often perceived in a different ways. It can never be assumed that everyone understands a message in the same way. The conclusion is that just providing correct knowledge regarding antibiotic resistance to providers and consumers is not sufficient although a pre-requisite for change in a desired direction. The process requires a more complex response to change behavior affected by various other factors.

(for further details see short paper, section - IV following this report)

**Location specific Integrated Antibiotic Resistance Management Strategy (LIARMS) Dr. A. J. Tamhankar**

It is generally observed that, though not necessarily in thinking but in practice, `control of antibiotic resistance‘ remains mainly in the realm of human use related clinical/hospital issues. A very large area of antibiotic presence, does not get the attention it deserves, when antibiotic resistance management is thought of. For example, non-human use of antibiotics (veterinary use) and presence of antibiotics in the environment due to contamination by human activities (hospital wastes & effluents of the antibiotic manufacturing units). Up to 50% of antibiotics produced is consumed in non-human use. Very little of the antibiotics taken by humans and animals for treatment is metabolised; the remnant is released in environment unchanged. These environmental pools form huge breeding grounds for resistance development, which if left unattended can nullify all the efforts directed mainly considering human use of antibiotics. The `total environment’ situation varies in every setting and needs to be addressed with location specific concerns taking into account all aspects. For this a Location specific Integrated Antibiotic Resistance Management Strategy (LIARMS) needs to be evolved in which human and veterinary health professionals, the NGOs and the community at large have a big role to play to ensure that all foci of antibiotic resistance development are accounted for and are paid the attention they deserve.

(for further details see short paper- section- V, following this report)

**Understanding the complexity of the determinants of antibiotic resistance. (Dr.Ravi Narayan)**

From the panel discussion so far we begin to understand the complexity of the problem of the antibiotic resistance. We need to appreciate different levels of factors and determinants.

**At the most primary level (in the interaction between the provider and the consumer) the determinants are:**

- Irrational use and abuse of antibiotics.
- Over use and Misuse
- Inadequate provider education
- Lack of patient education
- Problem of combination and substandard drugs
- Variation in patient level of nutrition and immunity
- Irrational consumer behavior.
- The problem of cost.
At the next level which could be termed, the public health level, the determinants would include
- Inadequate treatment guidelines.
- Inadequate infection control
- Lack of monitoring and surveillance
- Decline in research funds
- Inadequate control of veterinary use
- Environmental pollution as contribution to reservoir of resistant germs
- Inadequate primary health care.
- Inadequate public health systems.

Both these levels of determinants acting at clinical and public health level are further complicated and affected by health policy determinants which include
- Economic constraints
- Decreased investment in social sector including health
- Commercialization of health care and social security.
- International trade policies including WTO and IPR affecting cost and availability of drugs including antibiotics.
- New economic policies.
- Increase in social inequalities and marginalization due to flawed development policies
- Unsustainable development policies including displacement
- International travel

Any effort at tackling this problem will require a deep understanding of this complexity and an evidence based monitoring of each of these factors and their contribution to the problem before an action plan can emerge at a local, state or national level.
Some reflections on policy and action - The way forward in India (Dr. Sujith J Chandy),

As was mentioned by the previous speakers, the world is fast hurtling to a post antibiotic era where a majority of the antibiotics will not useful due to antibiotic resistance. This scenario which is already upon us, is largely due to inappropriate use of antibiotics. There are a number of factors which contribute to this misuse. These include:

- **The public** - They have poor knowledge of illnesses. They do not know that a common cold is due to viruses, and thus do not need antibiotics. They are ignorant of what an antibiotic is, and the consequences of irrational use.
- **The Doctors** - They are often pressurized to give antibiotics for fear of losing clientele. Patients often cannot afford a full course of antibiotics. Inadequate investigational facilities promote combination antibiotics and defensive medicine.
- **The Pharmacists** - They often give antibiotics without a prescription. Business rather than science often motivates this action.
- **The industry and medical representatives** - They often push irrational drug use more than any other player. After all, ‘money makes the world go around’! Doctors and pharmacists are open to incentives for prescribing and dispensing particular brands.
- **The Regulators** - Governmental regulations on antibiotic use in India are minimal. Policies put in place are not strictly implemented. Neither are there sufficient penalties for irrationally prescribing an antibiotic drug.
• **Other stakeholders** - Their contribution to irrational antibiotic use is far from minimal. Farmers, overuse antibiotics for both animal and agricultural purposes. This leads to cross resistance for humans. Complementary medicine specialists and quacks also use antibiotics although they have no expertise in it.

It can be concluded that the whole society is involved in killing the antibiotic and increasing antibiotic resistance. Therefore it is up to us, the society, to save the rational antibiotic movement. Strategies need to be multidimensional in method and multipartner in involvement in order to be executable, sustainable and successful. It could then be used to effect a lasting change to lead to rational use of antibiotics and lower levels of resistance.

The mechanisms and players who need to be involved are:

1. **The public** –
   - Make the public aware of illnesses, features and drugs needed. Knowledge is power, power to save!
   - Knowledge of the role of antibiotics and sensitization to the concept of antibiotic resistance should be disseminated
   - Knowledge needs to be disseminated attractively, in simple language and spread widely through media.
   - Schools, women’s groups, and leaders should be made aware of medicine misuse and its consequences.
   - Involve leaders of communities and opinion leaders
   - Role of NGOs and media in sensitizing the public should be properly explored

2. **The Prescribers** –
   - Bring together doctors in various forums
   - Present the facts, for example graphs on resistance and correlation to antibiotic overuse. Understanding is often the first step to action and reaction.
   - Allow them to ventilate problems in antibiotic prescribing. Use that information in planning of interventions
   - Involve them in making guidelines with evidence based input. Participatory decisions will have more compliance.

3. **The Dispensers** -
   - Pharmacists can act as a bridge between public and doctors! They should not be left out. After all, many patients go to chemist shops only. Discussions to bring out their problems can be useful.
   - Give them continuing education to keep them in tune with medical advances
   - Present facts on resistance and antibiotic use and discuss issues of ‘over the counter’ antibiotics
   - Issues of business vs. science vs. social responsibility should also be discussed
   - Policies such as an agreement to delay antibiotics, give simple drugs first and less combination antibiotics can be discussed
4. The Regulators -

- Government regulations should be reviewed and made with a view towards implementation.
- Government regulations should take to task companies which misinform doctors. The role of incentives in promoting irrational use needs to be studied.
- Regulation for drug waste and disposal needs to be implemented to prevent water contamination.
- Funding for research into existing resistance & use issues and its impact on overall health and economic implications is important. This will also help to involve the academia.
- Evidence in a truthful but intelligent way on the harm and the costs irrational drugs use is causing may spur the government to change policies. Public pressure also plays a part. Government should put antibiotic resistance and misuse on its priority list – as a public health emergency.
- **Public, NGO and activist pressure should play an important role in influencing government reaction & regulation.**

5. The Pharmaceutical Industry –

- Strict guidelines and penalties on unethical promoting, advertisement and incentives are important and it the various companies should be compliant with these guidelines.
- A joint agreement to give proper, scientific information to health professionals would be a good initiation.
- At the same time it is important to engage the industry on the issue of antibiotic resistance. On of the difficulties is the paucity of active research and development on new antibiotic molecules. Incentives by the government for research and development on newer antibiotics should be prioritized.
- Newer antibiotics which favor compliance should be thought off as well as a review of cost and price control – this may encourage completion of course.

6. Other stakeholders –

- Other players such as agriculturists and livestock carers need to be educated and made aware of the consequences.
- Antibiotic access should be restricted & use regulated based on scientific principles.
- Complementary medicine specialists need to use medicine of their own specialty rather than allopathic antibiotics.
- Complementary medicine specialists need to be restricted and educated on allopathic therapy.
- Quacks use allopathic drugs as concoctions. In India a significant number of the public visit quacks. Hence they need to be identified, involved, and educated in order to make them aware of the implications and consequences. Regulation alone may not work in practice.
Tackling antibiotic resistance is a multi sectoral, and multi dimensional challenge. As outlined above each of the stakeholders can play a part in leading to rational use of antibiotics. But they can play their part only if the ‘whole society’ is involved. What we urgently require is a commitment by providers, consumers, academics, researchers, policy makers and health and development activists, civil society and industry and every one else who can contribute to the solution- to work together in a campaign or movement mode to tackle the problem by action at various levels. The components of this campaign would include gradually, most of the following -

- Promoting rational prescribing practices
- Controlling combination and substandard drugs
- Controlling over the counter sales
- Cost control
- Strengthen Provider/prescriber education
- Promoting rational consumer education
- Strengthening multifaceted approaches for behavioral change
- Strengthening nutrition
- Antibiotic treatment- guidelines and schedules
- Strengthening infection control in health care institutions
- Improving the surveillance of resistance in hospital/health care
- Promoting more research on the problem
- Improving hospital waste disposal
- Promoting better guidelines for Veterinary use

![Diagram](source: CHC, SOCHARA)
While evolving such a campaign we should involve and link with existing and active health networks and movements to increase synergy and convergence.

Its therefore up to us to act and act fast. The consequences of antibiotic resistance can affect all of us and are already upon us whether we like it or not! By rationally using antibiotics, the society can save the society from destroying the society!! Can we rise up to the challenge, and save the antibiotics that save us!

II. The Global Challenge and the Swedish Experience

Prof. Otto Cars
STRAMA, Sweden

III. Antibiotic Resistance: A view and some lessons from a Community Hospital

Dr. Anurag Bhargava
Jan Swasthya Sahyog, Bilaspur
Introduction

Antibiotics are life-saving drugs. They are also one of the most commonly used drugs in the health system. Antibiotics are used throughout the health system with or without professional guidance, often without appropriate diagnosis being made prior to their use (Nordberg et al 2005; Sihavong et al 2007; Lan et al 2008). Antibiotics are in many settings prescribed or dispensed by health care workers or others without any or with limited education.

International as well as national strategies for control of antibiotic resistance often recommend education for health care professionals, including e.g. doctors, pharmacists and nurses and the public (WHO 2001, Okeke et al 2005, Mölstad et al 2008). Implicit in such campaigns are that they beside providing information also should lead to behaviour change. Interventions are however more likely to be effective if they while aiming at changing behaviour also include appropriate theories on behaviour change (Finch et al 2004). Further they need to acknowledge that people have various understandings of concepts such as e.g. “antibacterial resistance”. Qualitative studies show wide variations in views on various phenomenon in health care (Dall’Alba and Sandberg 1996, Stålsby Lundborg et al 1999a). The problem of resistance is not different. Recent studies among Swedish physicians shows variations in views on antibacterial resistance from seeing it is non-important in everyday practice or in the long-term perspective to seeing it a serious threat today as well as in the future and nationally as well as internationally (unpublished observations). Variations in views among care-takers regarding health seeking behavior
in relation to child infections is seen in Vietnam (Hoa et al 2007). It is likely that similar variation in views of the problem of antibacterial resistance and treatment of infections exists in all settings and among professional as well as consumer groups. Such variations in views need to be understood in order to design successful interventions aiming at changing behavior.

The aim of this paper is to present some theories for changing provider and consumer behavior in relation to antibiotic use. Further to give some examples of successful methods for interventions in this area.

**Behavioral change theories and their application for behavioural change of providers and consumers**

There are many different theories on behaviour change, why it happens, how it happens and various types of factors which influence the change. Below some of these theories are described in short and related to change in antibiotic behaviour.

**Focus on providers**

The traditional model of continuing medical education (CME) now often referred to as continuing professional development (CPD), consists of “information passing”, which has been described as pouring or pot-filling from “teacher” to “student”. The sole application of such a model has been criticised e.g. by Coles and Holm (1993) as such a linear communication is not considered optimal in the communication with providers. The providers’ experiences and expectations (Schön 1987) as well as their values and norms (Ajzen 1988) are important to incorporate or address in educational programs.

Educational models, encouraging reflection on practice, the use of feedback and small group learning including discussions are more likely to change behaviour. Learning based on experiences and the necessity to link new knowledge or new ways of behaviour to already existing practises has been stressed among authors writing on professional learning (Schön 1983, 1987, Mann 1994, Ramsden 1992). Schöns’ model, emphasizes “knowledge in action” and “surprise” as important drivers for professional change. The need to link theory to educational interventions aiming at changing antibiotic behaviour has been emphasized (Stålsby Lundborg 1999b; Finch et al 2004).
The “stages of change theory” or “the trans-theoretical model” was originally developed, describing the process a person goes through when giving up drinking and later smoking (Proschaska et al 1992). However, the five stages in this theory, pre-contemplation (not thinking about change), contemplation (considering change, but not ready for action), preparation (planning for change), action (change is initiated) and maintenance of changed behaviour, could equally well be applied for a change in prescribing behaviour in general (Thomson et al 2004; Shirazi et al 2008) and antibiotics in particular (Finch et al 2004). Persons in different stages of change are susceptible to different intervention strategies.

![Diagram of the stages of change theory](Fig 1. From IMPART study cited by Finch et al 2004.)

Change in prescribing behaviour could also be related to the concept of the prescriber’s "evoked set" of drugs (Denig 1994) and the process it takes to introduce a new drug within the evoked set. The evoked set could be compared to pre-set choices in a computer. Choosing between one of these pre-set alternatives is easy, while it is very difficult to choose something which is not among these alternatives. From this theory it is also seen that it is easier to substitute one drug with another one, rather than abstaining from prescribing.

The so-called Precede/Proceed model was developed for adult health education programs (Green et al 1988). In this model, predisposing, enabling and reinforcing factors are discussed in relation to behavioural change. Predisposing factors are knowledge and
attitudes which promote or inhibit a specific behaviour, such as knowledge about resistance. Enabling factors are individual or organisational factors that facilitate an action e.g. the availability of easily applicable treatment algorithms for various infectious diseases. Reinforcing factors are rewards or punishments that follow a behaviour. For example, when a new behavioural pattern is tried, e.g., prescribing in a different way than before, reinforcing factors, could be positive comments on the new therapy by peers or positive feedback from patients. Such reinforcing factors are often necessary to establish the new behaviour (Tamlyn and Battista 1993, Soumerai and Lipton 2002). These kinds of factors are related to motivation and overcoming barriers to change, as described by Gray (1997).

The relationship between the person, the behaviour and the environment and an emphasis on self-directed learning as a natural process was described in the “Social learning theory” (Bandura 1977). Further, awareness of a problem or a need on the part of the prospective adopter of a new technology was seen as important in a study on physicians’ views of change processes (Geertsma et al 1982). Common themes in all these models are the importance of other persons for inducing change and that change is a multifactorial event, complex to elicit.

" Academic detailing” is a concept introduced in the beginning of the 80s in the area of educational outreach to improve drug prescribing (Avorn and Soumerai 1983). “Academic detailing”, originally based on the social marketing approach, includes elements of most of the above mentioned theories. Theories on adult learning are, however, not explicitly addressed. "Academic detailing” has been summarised as follows (Soumerai and Avorn 1990) (i) assessment of motivation for current practices and barriers to change, (ii) focusing on specific physician categories, (iii) developing objectives for the education, (iv) establishing credibility (v) encouraging participation, (vi) using concise educational material, (vii) repeating key messages and (viii) ideally providing reinforcement through more than one visit.

Academic detailing is often considered among the most effective ways of changing prescriber behaviour in relation to antibiotic behaviour in ambulatory care (Schaffner et al 1983; Arnold and Strauss 2005). In general higher complexity models often refereed to
as multifaceted models seem to be effective in ambulatory care (Stålsby Lundborg et al 1999b; Arnold and Strauss 2005). In hospital care several types of interventions was shown effective (Davey et al 2005). However it is pointed out that the design of the studies as well as the selected outcome measures may affect the possibility to interpret and generalize the results.

It is important to note that educational interventions are relatively easy to implement in all kinds of settings as they can use local resource persons, which is relatively less costly (Santoso et al 1996; Okeke et al 2005). Interventions or intervention models applicable to educated professionals can also, in modified versions, be implemented for less educated providers (Chuc et al 2001; Stenson et al 2001).

**Special comments in relation to consumers**

Consumers are of course in many ways similar to providers when it comes to changing behavior and all the theories mentioned above are more or less applicable to consumers as well. The trans-theoretical or “stages-of change model” (Proschaska et al 1992) was as pointed out above originally developed for changing lay-peoples behaviour.

There are some features of consumers that need to be pointed out. First they can be divided into three groups, community members, not currently sick, patients and parents. These three groups need partly different types of messages. Also within the groups there are wide variations in knowledge and previous experiences as well as in socio-economic background and other variables such as language. Further, they are many more as compared to professionals. Thus mass-communication strategies are more important. TV supported by radio, posters for health-facilities, leaflets etc are often used in combination (Finch et al 2004, Sihavong et al 2006).

There is an intricate web of interactions within the consumer group as well as between the professional and consumer group. Providers’ perceptions of patients’ demand for antibiotics as well as an actual demand by consumers of antibiotics influences antibiotic prescribing and dispensing. Self-medication with antibiotics is an international issue (Grigoryan et al 2006, Sihavong et al 2006, Nyazema et al 2007) which increases access to antibiotics but also impose an increased risk of unnecessary use of antibiotics, a
tradeoff which needs special attention. One possibility in area with low access to formal health care providers is to acknowledge their importance and educate informal providers or non-physicians regarding e.g. antibiotic use (ADDOs project Tanzania).

**Conclusion**

Changing providers’ and or consumers’ behavior is a complex process. Providing knowledge in the form of evidence is in itself not enough even though it is in most cases a pre-requisite for acquiring a wanted behavior. In all cases, as clear messages as possible, needs to be given to avoid misunderstanding. The application of theories of behavioral change in intervention studies as well as in implementation of interventions is an important strategy to attain successful changes in outcomes. Studies evaluating the effectiveness of various types of interventions are needed. However, as in all implementation research, the context is of great importance whereas local validations of interventions will always be required.

**References**


V. Location Specific Integrated Antibiotic Resistance Management Strategy (LIARMS)

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Antibiotics are used to take care of the bacterial infections in the area of human and animal health, in agriculture, aquaculture, food preservation etc. They are also used in animal growth promotion. While the human use of antibiotics gets maximum recall that it deserves, uses other than in humans do not get the attention they deserve, despite the fact that as per WHO estimate half of the antibiotics produced globally are put to uses other than human use and of this, utilization in farm animals constitutes a very large share (WHO, 2002).

Once the antibiotics are enclosed in the packages in which they are put during manufacture; various human activities result in the contamination of the environment by antibiotics. For example they get into the environment through excretion by humans and animals (Brown et al. 2006), through disposal of unused antibiotics and as waste from pharmaceutical plants (Guardabassi et al.1998). Not all of the antibiotics used by humans and animals are metabolized by reactions like hydroxylation, cleavage or glucuronation, a considerable amount is excreted in the environment via urine and feces, which gets mixed with receiving waters (Yang and Carlson 2004). A number of investigators have reported up to several microgram / litre levels of pharmaceuticals including antibiotics in different environmental niches like municipal sewage, sewage treatment plants, surface and river water, groundwater, drinking water, sludge, manure, agricultural soil, coastal waters and sediments etc (Daughton and Ternes 1999; Hartmann 1998,1999; Hirsch et al. 1999; Huang et al 2001; Lindberg et al. 2004). Antibiotic residues may also be found in food products (Dutta, Barua and Dutta, 2003). In India, Larsson, Pedro and Paxeus (2007) have reported presence of antibiotics in waters receiving waste from pharmaceutical plants near Hyderabad. They have reported concentration of the most abundant drug,
Ciprofloxacin to be exceeding levels toxic to some bacteria by over 1000-fold (up to 31,000 µg/L).

It need not be brought out very elaborately that there are always enough bacteria in various biotic and abiotic environmental niches mentioned earlier and their interaction with the antibiotics leads to creation of foci of antibiotic resistant bacteria in the near and far environment of human beings. Studies in India show high levels of antibacterial resistance in bacterial samples from humans (Verma et al., 2000, Jain, Kumar and Awasthi, 2005) and also from samples from milk, cow stool, beef as well as poultry (Dutta, Barua and Dutta, 2003; Khan et al., 2002, Saxena, Singh and Lakhchaura, 2005). Resistant bacteria have also been reported from various other environmental niches (Ash et al. 1999; Watkinson et al. 2007). Use of animal growth promoters also leads to development of resistance.

The worrying aspect of antibiotic resistance is that development and spread of resistance in bacteria can get transferred from pathogenic to non-pathogenic bacteria and vice versa and also from bacteria from one niche to another niche and this has been reported very specifically in case of bacteria infecting farm animals whose resistance can further get transferred to those infecting humans (Angulo, Nargund and Chiller 2004; Kolawole and Shitlu 1997; Lu et al. 2002; Molbak 2004; Simango and Rukure 1991; WHO 2001). In addition to their impact on resistance development, antibiotics may also be implicated for genotoxicity.

It is a matter of global public health concern that pathogenic bacteria have developed resistance to antibacterials and it is more worrisome because it leads to increased deaths, prolonged treatments and economic losses (Melander et al. 2002; Coast and Smith 2003; WHO 2001, 2004, 2007a). Therefore this issue has been put on the global agenda time and again calling for determined actions (WHO, 2001, 2005, 2007b).

In tropical climate the impact of such resistant organisms could be highly significant in the spread of antibiotic resistance and we could be sitting on a `time bomb ticking very close to explosion`. To counter this situation, development and implementation of suitable interventions to minimize resistance development will be of utmost importance.
Antibiotics are life saving drugs and their use is essential to save human lives, however effective management and appropriate use strategies at every level can reduce the problems that may occur due to development of resistance in pathogenic bacteria. A very simplistic and effective approach is to focus on interventions that can optimize the use of antibiotics in every setting so as to reduce the amount of antibiotics entering the environment. This approach will no doubt reduce the antibiotics coming into the environment but it will not altogether stop the environmental contamination.

To develop suitable antibiotics resistance management strategy it is essential to delineate all the places of antibiotic existence such as places of manufacture, places of use, antibiotic providing agencies, all sources of antibiotic release into environment, agencies involved in management of all of these, pressure groups which can help implement antibiotic resistance management strategy etc. Taking all these stakeholders into account an antibiotic resistance management strategy can be planned and implemented, keeping in mind that non pharmacological preventive measures, especially keeping of good hygiene is acknowledged as highly important in human medicine as well as in veterinary medicine (WHO 2001).

An excellent example of antibiotic resistance management exists in Europe where growth promoters were banned by various nations in the European Union, which brought about a significant reduction in antimicrobial use in livestock without major negative impact on animal health, food safety or economic aspects (WHO 2002). But this is a very small area in the overall picture and a strategy which could have taken into account several aspects of antibiotic existence in environment would perhaps have resulted in a dramatic and long lasting impact.

Hospitals are the direct source of both resistant bacteria as well as unmetabolized antibiotics as these are mostly prescribed through hospitals. Antibiotics mixed with regular municipal wastewater can contaminate receiving surface and ground water as well (Rooklidge 2004). About 26500 million litres of wastewater is generated by cities in India out of which only about 25% gets any treatment and it is not known whether the treatment that is given removes antibiotics or not.
We (Cecilia Stålsby Lundborg, A.J. Tamhankar and APRIAM project group-unpublished observations) studied antibiotic residues in hospital wastewater in a town in western India in the project “Antibiotics as environment pollutants and resistance in waters in rural India - relation to antibiotic management” funded by Swedish Research Council and found abundant antibiotics contamination (ceftriaxone, ciprofloxacin, ofloxacin, levofloxacin, norfloxacin, sulphamethoxazole, tinidazole, metronidazole) in hospital wastewater -the lowest amount being that of metronidazole 2.5 µg/L and the highest amount being that of ciprofloxacin 236.6 µg/L. Further, the *Escherichia coli* present in this water were also resistant to several antibiotics like amoxicillin+clavulanic acid, ceftriaxone, ceftazidime, cefotaxime, cefuroxime, cefixime, amikacin, gentamicin, nalidixic acid, ciprofloxacin, gatifloxacin, levofloxacin, norfloxacin, lomefloxacin, sparfloxacin, imipenem, nitrofurantoin. This indicates that antibiotics and resistant bacteria are entering into Indian water sources. This indicates an emerging problem of antibiotic resistance in bacteria in non-clinical samples such as water and wastewater in India.

A typical flow path of antibiotic existence is- production/manufacture facility to distribution channel (dealers, retailers, providers) to a typical use area such as human and/or veterinary medicine utilization to waste to manure/sewage to soil/sewage treatment plant to surface water/sediment to ground water to potable water. Since every niche of these could also possess bacteria, the exposure of bacteria in all these niches can lead to existence of resistant bacteria in them. Thus without our realization we have all around us repositories of antibiotics and antibiotic resistant bacteria. Although various antibiotics have varying fate in the environment, for example aminoglycosides and β-lactams are least persistent in the environment (Huang et al. 2001) and Sulfonamides and fluoroquinolones are the most persistent in the environment followed by macrolides and tetracyclines (Jacobsen et al. 2004), still for various periods of time they persist in environment.

The foregoing information brings to our notice that antibiotic resistant bacteria and their ‘reason de etre’ the antibiotics, are present at several locations other than the hospital and
clinical environment where most of the interventional strategies get focused. These locations may vary from place to place i.e. they will be ‘location specific’ and will have locational characteristics. Therefore a prudent resistant management strategy will be to account for all the places of existence of antibiotics and antibiotic resistant bacteria in a target area and focus interventional strategies towards all of them simultaneously. If this is not done, while we are attempting to solve the problem at one/some compartment(s) of the ‘total environment’, the resistant bacteria breeding in the remaining compartment(s) of the ‘total environment’ will form a supply chain of resistant bacteria, sometimes failing our efforts and at other times giving an illusion of short term satisfaction. Thus in the management strategy the term ‘location’ will be context specific and may apply to a geographical location(s), and/or to a location of antibiotic reservoir and/or to a location of repository of antibiotic resistant organisms. Further, when attempting to develop such a strategy all imaginable and available components/solutions should integrated to form a ‘total solution’. Such an integrated strategy could then involve any and all types of interventions physical/mechanical/chemical/biological and should also involve all available prophylactic and cure practices from traditional as well as modern medicine. The location specific integrated resistance management strategy also needs to involve all relevant stakeholders to make it successful. Here the public health practitioners, the NGO’s and community leaders have an important role to play as pressure groups as they can only see to it that no stakeholders renegade from the commitment once it is made.

We (Tamhankar, Cecilia Stålsby Lundborg and others, unpublished observations) studied the knowledge and awareness of villagers/towners and their medical and veterinary drug providers in a project funded by Sida/Sarec and found that the awareness at every level regarding antibiotics use and resistance development is highly satisfactory and there is a highly receptive environment for campaigns explaining the correct methods of use of antibiotics and we feel that the time is ripe for developing and implementing location specific integrated antibiotic resistance management strategy.

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References


Additional resources on Antibiotic resistance

- **Websites**

  Visit ReACT:  [http://www.reactgroup.org/dyn/3,..html](http://www.reactgroup.org/dyn/3,..html)

  Visit STRAMA; [http://www.en.strama.se](http://www.en.strama.se)

- **Video- 'Antibiotic Resistance for Idiots'**-

  A short video for popular education raising the following questions

  Could antibiotic resistance be a metaphor for and even closely related to the imbalances we see in use of other valuable resources around the world today? When we talk of resistant bacteria we also need to ask which area of human intervention on Earth is not producing its own resistance. In fact if we consider our planet to be a living creature then global warming can also be interpreted as the Earth developing resistance to us and running a high temperature in the process!

  Why does the terminology of modern medicine draw so heavily from the dictionaries of war with the use of terms such as 'magic bullets', 'invasion', 'elimination' or for that matter 'resistance'? How does this mentality of the 'battle field' - with its core values of aggression and fear - affect the very questions of medical research leave alone the solutions that are sought for them? It is an approach to which 'resistance' can be the only logical outcome.

  Given the fact that microbes are so clever and successfully resist the best of our efforts to eliminate them – is it possible we can actually learn something from them? And can we imagine a future situation where we can coexist with microbes without constantly trying to kill them or provoke them into killing us?

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- **Blog - Indian Initiative for Management of Antibiotic Resistance**

  **IIAMR**

  Resistance to antibiotics is becoming a worldwide problem. To tackle this problem in India, the "Indian Initiative for Management of Antibiotic Resistance -(IIMAR)" was formed. All concerned are requested to join the initiative by sending email to antibio.resistance@gmail.com. Articles, links etc. are welcome at email address.

  As India is a continental country, to make quick contact possible between all concerned and for quick information dissemination to all concerned, the IIMAR has created a web presence at [http://save-antibiotics.blogspot.com/](http://save-antibiotics.blogspot.com/) which is the main website. To facilitate further web activity IIMAR has associate sites [http://wewantantibiotics.blogspot.com](http://wewantantibiotics.blogspot.com) and [http://antibioreistance.blogspot.com](http://antibioreistance.blogspot.com). Visit to anyone of them can lead a visitor to all the sites through urls. The sites are active and are updated routinely.

  The sites have a forum for discussion, give interesting news and videos, lead to useful literature and inform about current activities in India in the related field. The sites are for everybody to use. All are invited to participate . Due credit will be given to all those who contribute.

  Coordinators: Dr. A. J. Tamhankar, Dr. Mira Shiva and Dr. Sujith J. Chandy