Antibiotic resistance:

Emerging risks and the partnership solution

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Introductory message

In previous years, the annual report of Chief Medical Officer of Health for Ontario has informed the public and made recommendations on some of the most important causes of illness and death in this province. This year I have chosen to highlight a global health concern rather than a health threat specific to Ontario; an issue of serious concern which requires a dedicated and conscientious effort by all to control.

Resistance of bacteria to antibiotics – the drugs used to treat infectious diseases, has become a serious problem and threat to the health of many. Since the advent and widespread use of penicillin in the 1940s, dependence upon these important drugs has grown. For decades, we were protected by a wide range of antibiotics, fearless of the infectious diseases that afflicted previous generations. But now, increasingly, bacteria can resist the curative effects of these medications.

Despite continuing efforts of scientists, we can no longer rely upon the development of entirely new antibiotics to re-establish dominance over disease. Recent years have seen the successful development of fewer and fewer new antibiotics to replace those of diminishing effectiveness. Many of these new antibiotics are much more expensive or have more side-effects than their predecessors. Furthermore, bacteria can develop resistance to these new drugs.

Vigilance and dedicated adherence to an action plan to combat antimicrobial resistance is a must. Unless we recognise that antibiotic resistance is a serious problem, we face the prospect of life-threatening illnesses which cannot be effectively treated by any antibiotic. We must accept that this is a health problem which affects everyone and that it is surmountable with effort and dedication.

This report elaborates on the problem and the measures that hospitals, long-term care facilities and other institutions have initiated to protect our health. It also provides recommendations on how we can all do better. The recommendations are relevant to the citizens of this province, to the professionals, agencies and institutions which comprise our health care system, and to governments, the media and the public. A partnership which unites our initiatives with international efforts will help to preserve these important medications for future generations.

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The organisms that cause infectious diseases

Many types of organisms or germs cause disease in humans. The most significant are:

- **Bacteria**. These single-celled living organisms can live independently, but they also abound in the body, on the skin and the lining of the intestinal tract. They can cause diseases such as bacterial meningitis, bacterial pneumonia and strep throat, but many are harmless and some may even protect the body against disease.

Antibiotics are used to treat diseases or infections caused by ***bacteria***. They work by interfering with one of the processes vital to the survival of invading bacteria, such as the formation or integrity of the cell wall. ***Antibiotics are ineffective against viruses***. Today more than 270 different antibiotics are available in Canada to treat bacterial infections.

- **Viruses**. These simple organisms, comprised of a protein coat and genetic material, are incapable of independent existence. Viruses can only reproduce within the cells of a living host, causing influenza (flu), the common cold, most sore throats, herpes, chicken pox and many cases of bronchitis and otitis (ear infections). Some viruses can be treated with drugs used specifically for viral infections, called antivirals. There are only a very small number of anti-viral drugs currently available to treat viral infections.

- **Fungi**, or moulds, are simple multicellular organisms that can cause skin infections such as athlete's foot and yeast infections.

- **Parasites** are more complex multicellular organisms that live on animals or plants and can cause infections such as malaria.

Antibiotics: the miracle drugs

The very first antibiotic was penicillin, discovered by Sir Alexander Fleming in 1929. He put disease-causing bacteria in a petri dish and found that Penicillium mould inhibited their growth. During World War II, penicillin saved literally thousands of people from death from wound infections. Over the next decades, penicillin and subsequent antibiotics significantly improved the life expectancy of millions, more by effectively treating a wide variety of formerly lethal diseases, such as pneumonia and tuberculosis.

The other side of the miracle: antibiotic resistance

Over time, with overuse and misuse, coupled with the natural mutation abilities of bacteria, antibiotics have become less effective against bacteria. Researchers have discovered that many bacteria eventually develop the means to prevent antibiotics from killing or harming them.

How does this phenomenon, known as *bacterial resistance*, occur?

A person suffering a bacterial infection will usually have hundreds of millions of bacteria in his or her body. The antibiotic drug attacking this large group of bacteria will kill the bacterial cells that are highly sensitive to it. When bacteria reproduce, a certain number will mutate (i.e. change in genetic composition from the parent). Mutations can occur in bacterial genes at a rate of about one in one hundred million. Through natural selection and evolution, a strain of bacteria will eventually develop a spontaneous mutation, or change in the genetic code of a bacterium, which renders it resistant to an antibiotic. This results in the potential for a small number of bacterial cells to survive treatment because they have developed a natural resistance to the antibiotic being used.

Those bacterial cells that survive the initial antibiotic attack will continue to grow and reproduce. Over time, in the presence of an antibiotic, the most resistant bacterial cells will out-compete and out-number all the other bacteria. In other words, the resistant bacteria take over.

Bacteria can also exchange genes between different strains and species, particularly through transferring pieces of genetic material known as *plasmids* and *transposons*. They can thus, easily pass antibiotic resistance from one strain to another.

A bacterium acquiring a resistant gene.

Researchers have discovered that many bacteria eventually develop the means to prevent antibiotics from killing or harming them.

The high cost of antibiotic resistance

To cope with antibiotic resistance in a particular patient, antibiotics must be administered in progressively higher concentrations to treat a given bacterial infection. But from the very first dose, some antibiotics begin to kill off normal or "good" bacteria – bacteria that are beneficial to the body. Lacking the constraint imposed by competitive "good" bacteria, it becomes easier for disease-causing bacteria to gain a foothold.

To compound the problem, **organisms that are resistant to one drug are more likely to become resistant to others**. The bacteria *Streptococcus pneumoniae (S. pneumoniae)*, for instance, which can cause pneumonia, meningitis, ear infections, and blood stream infections has become resistant to penicillin and now demonstrates some resistance to several other antibiotics.

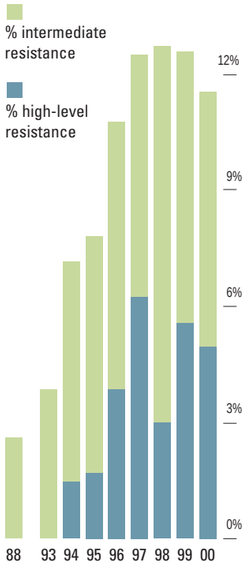
The more antibiotics are used, the greater the risk of organisms developing resistance to them. There is a strong association between prior use of antibiotics and the development of antibiotic resistance. Several studies have found that patients who had recently received antibiotics were more likely to carry or be infected by antibiotic-resistant *S. pneumoniae* than those who had not receive antibiotics.

Antibiotic resistance can seriously affect the progress and outcome of disease and can significantly impact the cost of treating disease. In health care institutions where patients with serious antibiotic resistant bacterial infections are admitted, these bacteria may be passed from person to person, increasing the risk and burden of antibiotic resistance. Antibiotic resistance is a greater problem in hospitals and nursing homes than in the community. Severe infections due to antibiotic resistant bacteria are associated with longer hospital stays and increased mortality. In addition, infections caused by resistant organisms may require treatment with more expensive and more toxic antibiotics, more frequent and sophisticated laboratory tests, and longer courses of antibiotics. This has great impact on the financial costs of treating a disease.

Resistant strains of bacteria are found around the world: The same types of antibiotic resistant organisms have been found in many different countries. There are a number of reasons for this phenomenon: antibiotic prescribing practices of health professionals; travel of individuals infected with resistant organisms; lack of effective control measures, or poor adherence to them; and, inadequate infra-structure necessary to support control measures (i.e. surveillance and monitoring).

Most significantly, many bacteria that cause infections are no longer susceptible to the antibiotics that were once effective against them. These include bacteria causing important community-acquired infections such as gonorrhoea, bacterial pneumonia and tuberculosis, and bowel bacterial infections of several types, as well as *Staphylococcus aureus (S. aureus)*(a common cause of a variety of skin and soft tissue infections and more serious infections in hospital) and some intestinal infections, such as *Shigella, Salmonella* and *Campylobacter*.

Penicillin resistant *S.pneumoniae* Ontario isolates 1988, 1992-2000



Tuberculosis: a case study in the evolution of antibiotic resistance

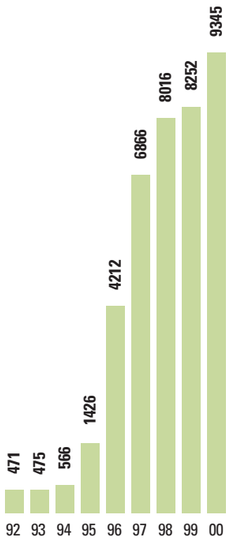
Fifty years ago, tuberculosis was a dreaded and frequently lethal disease. Today, thanks to antibiotics, most cases of tuberculosis do not require hospitalisation, and can be treated at a cost of about $2,000. Successful treatment of the disease has always required administration of at least three different antibiotics, taken over several months. The combination of medications is necessary to kill off all strains of tuberculosis bacteria. Unfortunately, some people may stop taking some or all of the drugs because of undesired side-effects. In some countries, people may be non-compliant with the duration of treatment because of cost or lack of understanding. As a result, virulent new strains of tuberculosis resistant to two or more of the antibiotics used to treat this disease have emerged. Multiple Drug-Resistant TB (MDR-TB), has become increasingly common in the U.S. Mortality for MDR-TB is high; it typically requires 42 days of hospitalisation and treatment costs run higher than $250,000.00. So far, in Canada, the number of people with MDR-TB has remained low, substantially because of universal access to anti-tuberculous medications, and public health surveillance and control measures.

The importance of controlling antibiotic resistance in institutions

Antibiotic resistant organisms (AROs) are a concern not just in hospitals, but in seniors' residences and child care centres as well. The patients, residents and children in hospitals, long-term care facilities and day care centres are particularly susceptible to antibiotic resistance. The people in these institutions are also more likely to need antibiotics than the general population and may require one or more of these drugs to treat life-threatening health conditions. Very sick or susceptible individuals are also more vulnerable to infection when exposed than healthy individuals. While in hospital, very ill or susceptible patients are additionally vulnerable to bacterial infections because of intravenous or intra arterial catheters or surgical wounds. Without the effective antibiotics needed to treat their infections, these patients may suffer serious complications, succumb to permanent disabilities or even die. Thus, prudent and appropriate use of antibiotics is vital in our fight to maintain the effectiveness of these antibiotics in treating clinical infections caused by the bacteria that they target.

We are now seeing and experiencing the consequences of using antibiotics. *S. aureus*, an organism that lives on the skin of about 20% of healthy people without causing disease is the most important cause of infections in hospitalized persons around the world. The strain of *S. aureus* resistant to the antibiotic methicillin, called *Methicillin-Resistant Staphylococcus aureus*, or MRSA, evolved soon after the drug was introduced in 1960. MRSA is a dangerous pathogen (disease-causing organism)

Number of patients colonized/ infected with MRSA, Ontario, 1992-2000



and is highly resistant to nearly all antibiotics currently used, with the important exception of vancomycin. Unfortunately, MRSA is now widespread in major urban hospitals in the United States, where rates of resistance increased by about 1200% from 1975 to 1991. In US hospitals, more that 40% of all hospital *S. aureus* strains are MRSA.

Within Ontario, MRSA was first reported in 1981. A survey of the incidence of resistant organisms in Ontario in 2000 reported over 9,000 (9345) Ontario patients were colonized or infected with MRSA. This represents a 20-fold increase from only six years earlier, in 1994. The problem is not confined to any particular hospital or geographic region. Almost all hospitals in Ontario have reported at least one case of this organism. The exceptions were small, northern hospitals. The majority (85%) of these organisms were acquired in a hospital or long term care facility, but some were acquired in the community.

A five year surveillance program with 35 sentinel hospitals across Canada identified over 4,500 (4,502) new cases of MRSA in 1995 through 1999. During those five years, the proportion of strains that were resistant to all penicillins and cephalosporins (that is, were MRSA) increased from 0.5% of all the *S. aureus* isolates to 6.1%. Where the site of acquisition was known (3,009 cases), most were acquired in a hospital or long-term care facility (86% and 8% respectively).

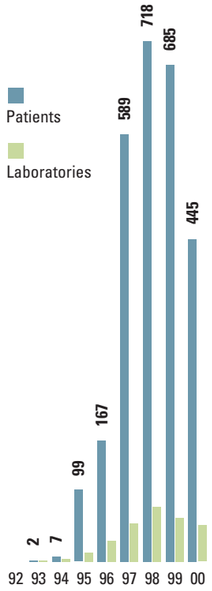
MRSA can be contained. In Denmark, which developed comprehensive control programs, the proportion one of the most frequent strains of *S. aureus* with multi-resistence, declined from 24% in 1969 to 6% by the late 1980's. It has remained at this low level ever since. Resistance among isolates from diagnostic submissions has been stable over the last five years. Since 1996 there have been less than 100 MRSA isolates per year identified in all of Denmark.

All hospitals which reported for the 2000 Quarterly Management Program – Laboratory Services, Laboratory Proficiency Testing Program survey, had an admission screening program to address antibiotic resistant organisms. 92% of these hospitals' programs are now consistent with current Ontario recommendations (i.e., screening patients who have been in a health-care institution within the past six months). In addition, since 1998, 67% of all hospitals report performing screens of in-patients on an intermittent basis.

Another bacteria, *Enterococcus*, is a bacteria normally found in the bowels of healthy individuals. It causes problems only in those who are very sick or who suffer from suppressed immunity (diminished ability to fight infection) – a population of people in large numbers in hospitals. A strain of *Enterococcus* bacteria known as Vancomycin Resistant Enterococcus, or VRE, has now developed resistance to all antibiotics – including vancomycin. Should the VRE bacteria manage to transfer its vancomycin resistance to MRSA, the resultant new strain of bacteria will be capable of causing serious disease that is resistant to all currently-available antibiotics.

A recent public opinion poll showed that close to 50% of Canadians believed that antibiotics are effective against viral illnesses.

Number of VRE reported in Ontario laboratories 1992-2000



VRE are identified less often and emerged later than MRSA. The first case was reported in Ontario in 1993 (CCAR 2001 Surveillance). The first outbreak of VRE occurred in Canada in 1996 (CCAR 2001 Surveillance:2). By 1999, the number of Ontario patients identified as having VRE had increased to 685. However, this number dropped to 440 in 2000 as a result of province-wide control measures.

Additional bacteria, for example *Klebsiella* and *E coli*, have also developed the ability to resist antibiotics. These are extended-spectrum beta lactamase-producing bacteria (ESBL), and strains of these bacteria which are resistant to quinolones (e.g. ciprofloxacin); a small proportion of these strains are multi-drug resistant. These bacteria most often cause urinary tract infections, but can also cause pneumonia and blood stream infections. Ontario experienced its first major institutional outbreak of ESBL-containing bacteria cases in institutions in 2000. ESBLs currently constitute approximately 1% of all E coli isolates.

The cost of antibiotics in agriculture

Sometimes diseases in humans and domestic animals are caused by the same or related bacteria. Antibiotics are used as an effective treatment in veterinary medicine and are also commonly used to promote growth in food animals. It is therefore, not surprising that antibiotics are widely used in agricultural and animal husbandry settings – private as well as commercial.

The use and administration of antibiotics in agriculture in Canada is regulated. Nonetheless, they are widely used, and many professionals are concerned that antibiotic-resistant organisms from animals, such as some strains of *Salmonella, Campylobacter, Enterococci, and E. coli*, could infect humans. Although it is difficult to establish a clear connection, when animal bacteria are exposed to an antibiotic used in animals which is related to an antibiotic used in humans, they may develop common resistances; the antibiotic resistant organisms in animals or their antibiotic resistant genes could spread to humans. For example, a strain of *Enterococcus* resistant to the antibiotic vancomycin has now been linked to the use in European animals of a related drug, avoparcin.

Much more research on this subject is necessary. However, most experts, including the World Health Orgaization believe that certain classes of antibiotics should be reserved exclusively for humans. A growing body of evidence suggests that the use of antibiotics in agriculture contributes to antibiotic-resistant organisms in humans.

And in 1997, the World Health Organisation (WHO) expressed concern that excessive use of antibiotics, especially as growth promoters in animals destined for human consumption, resents a growing risk to human health.

In 1998, the European Union followed WHO recommendations and banned the use for animals of antimicrobials prescribed for the treatment of human infections as well as all antibiotic use for growth promotion in animals. Recent studies would appear to offer testimony to the wisdom of such legislation. In Germany, Denmark and Switzerland, the ban of avoparcin as a growth promoter appears to have been associated with significant decrease in the prevalence of VRE bacteria both poultry and humans.

At Health Canada, the Laboratory for Food-Borne Diseases and Zoonoses is initiating surveillance strategies for antibiotic resistance in agriculture.

Antibiotic resistance affects us all

Most people who are sick see their family doctor first. Not surprisingly, these physicians write the bulk of antibiotic prescriptions – more than 80%. And more than three quarters of the prescriptions written by family doctors are for antibiotic treatment of ailments such as ear infections, sinusitis, sore throats, the common cold, the flu and bronchitis. Antibiotics are an effective treatment for some of these illnesses. But the common cold, the flu and many cases of bronchitis are illnesses caused by viruses. **Antibiotics have no ability to kill viruses**. Decongestants and pain relievers may provide some relief from the symptoms of these illnesses, but the body's own natural defences, not antibiotics, must conquer the disease.

Doctors who have been surveyed about drug use say that they usually prescribe antibiotics because they lack the time needed to explain why these drugs might not be needed or because they are responding to unrealistic patient expectations. Patients may insist on antibiotics for their ailment, believing that an antibiotic will cure them or make them feel better faster, misunderstanding of the etiology of their illness (i.e. viral vs bacterial), or because of inappropriate external demands (e.g. child care facilities or schools requiring use of an antibiotic to re-admit a child into care).

In 1996, Canadian doctors wrote more than 26 million prescriptions for antibiotics. Ontario doctors wrote more than 10 million prescriptions (nearly 40% of all prescriptions).

How we can fight back

Activities against *antibiotic resistant organisms*

Everyone can take action to help control the growth of antibiotic resistant organisms and help preserve them for the future. Each of us can help to educate others, to act in responsible ways to improve the effectiveness of current antibiotic treatments, and to protect our future health against antibiotic-resistant bacteria.

However, individuals must be supported by a greater infrastructure to effect significant and lasting change. Governments and institutions must play their parts. On a global scale, the WHO has addressed this issue and have recently published a report on this topic: *Overcoming Antimicrobial Resistance: World Health Report on Infectious Diseases 2000*. This report highlighted the problems of major infectious diseases including tuberculosis, malaria, AIDS, pneumonia and diarrheal diseases.

In the United States, an interagency Task Force on Antimicrobial Resistance with broad representation developed a public health action plan to combat Antimicrobial Resistance.

In Canada, the federal government developed an interdisciplinary committee (the Canadian Committee on Antibiotic Resistance (CCAR)) in 1999 to address the issue of antimicrobial resistance.

Controlling antibiotic resistance in the community

Promoting appropriate antibiotic use: it can work!

In 1996 and 1997, the pharmaceutical industry, the Ontario Ministry of Health, local physicians, pharmacists, nurses, and thousands of Port Perry residents worked together and successfully and significantly reduced their use of antibiotics. Participants in a six-month project entitled Pilot for Appropriate Anti-Infective Community Therapy:

- used fewer antibiotic prescriptions;
- used less expensive, narrow-spectrum antibiotics more often;
- were diagnosed with viral infections more frequently; and
- did not visit their doctor any more often for infections than they had before.

At the outset, doctors and pharmacists took professional education sessions focused on the Ontario Anti-Infective Guidelines for Community-Acquired Infections, and a comprehensive public education and information campaign educated consumers about differences between viral and bacterial infections as well as antibiotic usage.

Another project to contain the use of antibiotics also used educational efforts and community participation to optimize the management of respiratory tract infections and decrease the inappropriate use of antibiotics. *The Bugs and Drugs* project began in March 1998 in Alberta, which had high rates of penicillin-resistant *S. pneumoniae*. An Antimicrobial Pocket Reference was distributed to physicians and pharmacists in Northern and Central Alberta. The pilot project was completed in 1999 and the results showed that the community of Grand Prairie had reduced their antibiotic use by 12%. This project is still underway and involves a well developed public education campaign, educational credits for physicians, and educational materials for the public, parents, teachers, and children.

In 1999, the Ministry of Health and Long Term Care's expert drug advisory committee, the Drug Quality and Therapeutics Committee (DQTC) completed a review of all antibiotics listed in the Ontario Drug Benefit Formulary/Comparative Drug Index (Formulary) to ensure that all antibiotics listed in the Formulary were being used in accordance with current clinical evidence.

This review complements initiatives undertaken by the ministry's Public Health Branch (e.g. Strategic Planning on Antibiotic Resistance in Ontario), Health Canada, other community efforts and efforts in other international jurisdictions to address this serious public health issue.

Individuals

Every individual can play an important role in reducing inappropriate use of antibiotics:

- Communicate with your family doctor. *Do not insist on an antibiotic if your doctor says you do not need one*. Ask him or her if an antibiotic is really needed.
- Take medication as prescribed. Do not stop taking a drug early even if you feel better.
- Keep your influenza vaccination status up-to-date so your body can fight this disease itself.
- Get your pneumococcal vaccination if you are eligible, so your body can fight these diseases itself.
- Do not use drugs left over from a previous illness, or those prescribed for someone else.

Health care professionals

Only a health professional licensed to prescribe and who has assessed a particular illness in a specific patient can make the decision about whether an antibiotic should be prescribed, and which one. Ontario health care professionals may be able to improve their use of antibiotics by consulting the Ontario Anti-Infective Guidelines for Community-Acquired Infections, or an equivalent resource.

A study of the Saskatchewan Drug Database which analysed data on all respiratory infections in children less than five years of age showed that in 1995, 56% of children in Saskatchewan visited a doctor for a respiratory infection, and 64% of these children received an antibiotic prescription. Compliance with appropriate guidelines would have resulted in an 85% reduction in antibiotic prescriptions in this group.

The Canadian Committee on Antibiotic Resistance (CCAR) reports that over half of the antibiotic prescriptions for Canadian preschool children were unnecessary. In addition, "urgent care physicians were more likely than pediatricians or family physicians to prescribe immediate antibiotics and to disregard guidelines when dealing with complaints of acute otitis media." Three conditions (acute otitis media, pharyngitis and bronchitis) account for more than 80% of antibiotic prescriptions.

In addition, health care professionals must:

- Educate your patients. Help them understand that unnecessary use of antibiotics is not best for their own health as well as the health of the public.
- Consider delayed-action prescriptions (for use only if symptoms persist), or non-prescriptions (written advice about managing the illness without antibiotics).
- Communicate with your patients at the visit. Studies suggest that patients' satisfaction with treatment is related to the time spent in consultation with a physician, rather than whether a drug was prescribed.
- Use laboratory tests appropriately to support your diagnosis and select the right antibiotic.
- Make sure your patients are up-to-date on their influenza and pneumococcal vaccinations.

Child care facilities

- Implement and enforce regular hand-washing and other simple but vital hygiene practices! Studies in day cares have shown that washing hands frequently during the day substantially decreases illness due to infections.
- Periodically review the policies around exclusion and readmission of children with respiratory infections. Make sure that antibiotic therapy is not a condition for readmission to your centre.

Studies in day cares have shown that washing hands frequently during the day substantially decreases illness due to infections.

Health care institutions and long term care facilities

To prevent the spread of antibiotic-resistant organisms, many Ontario health care institutions have already implemented systematic detection methods and preventive measures for antimicrobial resistance. Programs that address resistance at multiple levels are the most effective.

- Hospitals should put strict infection control measures in place for patients with resistant organisms, such as isolation in private rooms, gowns, gloves and masks. Hospitals in Ontario should implement screening programs to identify high-risk patients.
- Develop and implement guidelines, formularies (the official guidelines for drug use developed by each hospital), protocols and drug utilization reviews to ensure that antibiotic use is optimized, and that the risk of antimicrobial resistance is considered in decisions about antibiotic prescribing.
- Maintain good general hygiene and infection control measures – particularly handwashing. For instance, many hospitals, nursing homes and home care agencies have implemented the use of alcohol handrubs improve hand disinfection, especially where sinks are not readily available;
- Provide ongoing ducation for health care professionals, patients and families regarding appropriate antimicrobial use, and other practices (e.g. immunization, hand hygiene, other infection control programs) to prevent and reduce the impact of antimicrobial resistance.
- Ensure surveillance for changes in the occurrence and pattern of antimicrobial resistance in different bacteria. and other microbes (e.g. viruses).

It is also important that health care institutions:

- Constantly evaluate programs to control antimicrobial resistance as new evidence appears.
- Work closely with other organizations to develop regional and national surveillance and control programs, so that they share the growing body of knowledge about resistance and the responsibility of modifying existing strategies collectively.
- Allocate adequate resources for laboratory testing, data collection and monitoring, screening and infection control.
- Support regional and national educational programs for health care professionals, patients, and families regarding appropriate antibiotic use in hospitals and long-term care facilities.
- Work to ensure that patients and their families are equipped with the information and skills to prevent and control antibiotic resistance.
- Ensure that all personnel adhere to infection control procedures appropriate to the organism and the situation, especially hand hygiene and barrier precautions (masks, gowns and gloves).

Agriculture and farming

Relevant agencies at federal and provincial levels must continue to be vigilant with research, testing and regulatory requirements. Health Canada is developing a national surveillance system for antibiotic resistance in the agri-food and fish-farming industries. The agricultural industry must:

- Use antibiotics prudently and comply with regulatory limits on their use.
- Emphasise good animal husbandry practices, such as providing animals with adequate and clean living quarters.
- Work with governments to move away from using antibiotics as growth-promoters.
- Collaborate in the monitoring of antibiotic use and surveillance of antibiotic resistant organisms in veterinary and agricultural sectors to better understand the prevalence of resistant bacteria along the food chain and to develop appropriate control and prevention measures.

Public health organizations

Public health organizations must assume a leadership role at the local level and help people work together to control the emergence and spread of antibiotic resistant organisms in their areas. They should:

- Educate the public and health professionals about the antibiotic resistance, the importance of infection control practices, vaccination and the proper use of antibiotics.
- Participate in monitoring the trends of antibiotic-resistant organisms in their communities and institutions to help obtain a clear picture of the extent and nature of these organisms and their control.
- Coordinate the development and implementation of regional programs to optimize antibiotic use in the community and in institutions, and to prevent the spread of antimicrobial resistant organisms in health care institutions.

The pharmaceutical and related industries

These groups should:

- Support public and professional education efforts that promote appropriate antibiotic use.
- Develop and use improved laboratory tests capable of rapidly identifying infections and determining patterns of susceptibility to antibiotics.
- Ensure that advertising and promotional campaigns for new antibiotics emphasise the long-term health benefits of using these drugs prudently.

Policy-makers, working together with all parts of the health care system

In this country, the CCAR, a multi-disciplinary organization, now facilitates cooperation among many agencies, and has developed a National Integrated Action Plan. An important goal of this plan has been to encourage concerned organisations and agencies to reduce prescriptions for unnecessary antibiotics by 25% within three years – largely through a focus on community-acquired respiratory infections. CCAR efforts also focus on resistance surveillance and infection prevention and control. This includes providing information to medical professionals and the public, generating reports on the issues and encouraging health care and agricultural policies and practices which limit resistance.

In Ontario, the Ministry of Health and Long-Term Care is in the process of identifying priority areas to target, so we can address the problem strategically rather than on a hospital-by-hospital basis. To this end, the ministry brought physicians and scientists in Ontario together to work on the "Control of Antimicrobial Resistant Organisms (ARO)" through a project to address prudent antibiotic use and infection prevention and control in the form of a province wide education program to reduce inappropriate antibiotic use and to promote appropriate current infection control practices in institutions.

In coordination with initiatives on antibiotic resistance of Ontario's Public Health Branch of the Ministry of Health and Long-Term Care, (i.e. Strategic Planning on Antibiotic Resistance in Ontario) and Health Canada, more than 50 antibacterial antibiotics were examined in a comprehensive review of all antibacterials listed in the Ontario Drug Formulary by a group of experts in 2000. As a result of this review, the formulary changes were mailed to all health practitioners in Ontario in February 2001.

In addition to these initiatives we need:

- A central agency to collect, analyse and disseminate information relating to antibiotic resistance,

Hong Kong has an established surveillance system of 45 sentinel physicians in private and government out-patient practice. They track potentially invasive bacteria cultured from nasal and throat swabs, stool samples and urine and other specimens, and test the organisms for their patterns of antibiotic resistance. In 2000, 15% of Staphylococcus aureus isolates were found to be methicillin resistant. They also noted an increase over previous years in quinolone resistance in bacteria causing urinary tract infections, and noted concerns of resistance for salmonellae and pneumococci.

- Although Ontario has provincial standards, there needs to be **national** standards for the laboratory detection of antibiotic-resistant bacteria and for proficiency testing and staff training in laboratories, plus
- **National** standards for infection control in hospitals and other health care institutions and for programs to prevent and control antimicrobial resistance;
- Coordinated national and provincial surveillance systems to monitor current issues, and to detect emerging problems in antimicrobial resistance.

We also need to:

- Develop educational materials for the public and have them available in doctors' offices, pharmacies, hospitals, and other places accessed by the public.
- Encourage professional groups to develop, refine and disseminate evidence-based guidelines on the use of antibiotics and on infection control practices, supported by continuing professional education.
- Take measures to ensure we transfer all information about patients infected with antibiotic-resistant organisms between institutions and community agencies.
- Encourage health care professional groups and associations for physicians (e.g. the Council of Faculties of Medicine, the Royal College of Physicians and Surgeons and the College of Family Physicians) pharmacists, nurse practitioners, and dentists to develop up-to-date curricula on this subject.
- Encourage granting agencies to fund research on antibiotic resistance as well as rapid affordable systems for diagnosis and susceptibility testing.
- Ensure that antibiotics remain available through prescription only, rather than as over-the-counter medications.
- Determine rates of antibiotic resistance in hospitals and long-term care facilities and readily communicate this data to these institutions and to laboratories, so they can establish good antibiotic management and infection control programs.
- Develop more projects to encourage optimal antibiotic prescribing in hospitals, community and child care settings.

Conclusion

Effective control of antibiotic resistance requires a continuing strong partnership between all parts of the health care system and the international community. Our mutual goals must be:

- **to improve surveillance and research**, so we can more clearly see what is happening in antibiotic resistance and make decisions based upon the best evidence;
- **to slow down the progress of antibiotic resistance by using current and future antibiotics more appropriately**; and
- **to use other methods to combat infections and prevent the spread of resistant organisms**, such as infection control measures and immunisation.

Health professionals, government, industry and the public in Ontario all have essential roles to play. The synergy of cooperative and effective partnerships can most successfully fight this growing health threat. That would be a victory as significant as the original discovery of penicillin.

Acknowledgements

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