Swedish Civil Contingencies Agency

Antibiotic resistance and societal security

What would a more far-reaching antibiotic resistance mean for societal security?

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Swedish Civil Contingencies Agency (MSB)

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Content

Summary

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Ever increasing attention is being paid to the challenge that society faces with the continuing development of antibiotic resistance. Many years of excessive and inappropriate use of antibiotics has accelerated the development of resistance. It is a problem concerning several societal sectors and services, and as a consequence must be dealt with at all levels: locally, nationally and internationally.

In accordance with the Swedish Civil Contingencies Agency's (MSB) mandate to analyse particularly serious vulnerabilities, threats and risks, the MSB has in this study investigated what an extensive antibiotic resistance could entail for societal security. Increasing antibiotic resistance threatens not only lives and health but might also affect vital societal functions. Examples include the medical services, pharmaceutical supplies, care facilities, food, drinking water supply, sanitation and the fire and rescue services. Public trust and confidence in societal institutions might diminish and the societal costs of antibiotic resistance could be extensive.

A more extensive antibiotic resistance could also complicate the management of certain types of emergencies. Unless the development of antibiotic resistance can be slowed down, medical care in the future could encounter major problems regarding treatment of injuries caused by big accidents and crises, or with the bacterial secondary diseases (sequelae) that follow a pandemic.

In conclusion, this study of antibiotic resistance highlights the complexity of the problem and the importance of a proactive approach. This means monitoring the development of resistance carefully from the perspective of various disciplines and working in a preventive manner. The MSB is following the development from a multidisciplinary and holistic perspective and is analysing the impact on societal security as a whole.

For MSB, it is also important to continue monitoring how the development of antibiotic resistance might affect the agency's own areas of responsibility, such as rescue services (emergency response) and international disaster relief and development operations.


LIEBHERR

Introduction

1. Introduction

Antibiotic resistance is a growing problem which demands a response from an ever wider circle of stakeholders in society. A development where common infections can no longer be treated in such a simple manner, and modern medical services no longer run as they are run today would have very major consequences for society at large. The challenge now facing society with the spread of resistant bacteria has been highlighted, for example, by the World Economic Forum in the report *Global Risks 2013*, and in a joint statement by the G8 countries in 2013.[1]

The Swedish Civil Contingencies Agency's (MSB) Strategic foresight aims at creating understanding for the challenges and possible scenarios that the area of civil protection and public safety (civil contingencies) may encounter in the future. Through long-term strategic analysis, different *possible* future scenarios are subject to investigation as well as how these might affect the security of our society and its institutions as a whole.[2]

One such *possible* future scenario is a world with significantly more extensive antibiotic resistance where only a few active antibiotics are left.

Sweden, in comparison with other countries, has a relatively long history in the work of fighting resistant bacteria. Within many sectors, such as medical care, infectious disease control, animal health, agriculture and the food industry work has been undertaken over many years in mapping and preventing antibiotic resistance. But a more cross-sector, holistic view of the problem is desirable, and the possible consequences for societal security if a more extensive antibiotic resistance is considered has not previously been analysed.

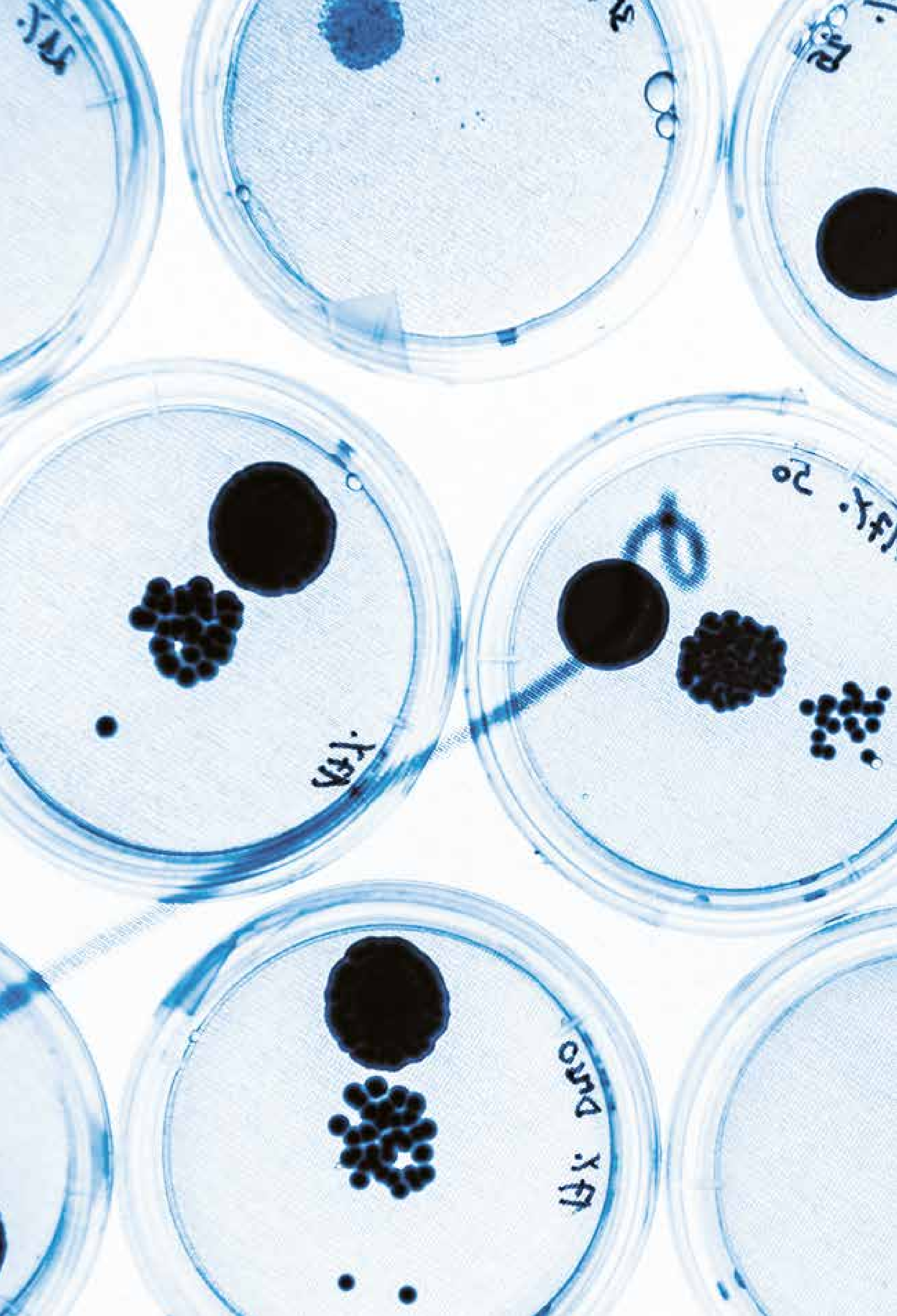
This report is an abbreviated version of the original report in Swedish.

1.1 Purpose

The purpose of this study is to investigate how a more extensive antibiotic resistance could affect society's overall security. The question at issue to be elucidated is as follows: what consequences would a more far-reaching antibiotic resistance imply for societal security?

A "more extensive antibiotic resistance" refers to a future scenario where there are only a few active antibiotics left to use for treatment of infections since a very large share of the bacteria are multidrug resistant. (More about this scenario in Section 3.1).

The goal of the study is to provide MSB and other stakeholders within the area of civil protection and emergency preparedness with documentary material concerning how to approach antibiotic resistance as a risk and to work further with antibiotic resistance on the basis of a societal security perspective.



About antibiotic resistance

2. About antibiotic resistance

2.1 Antibiotic resistance is already a major problem

The development of antibiotic-resistant bacteria has been taking place more quickly and more widely than anticipated as a result of many years' excessive and inappropriate use of antibiotics over the world. With a more rational use of antibiotics the development of resistance could be lessened, although not wholly stopped.

In many parts of the world, antibiotics are used as a growth-promoting agent for animals in food production. In Sweden (since 1986) and the EU (since 2006) it is only permitted to give antibiotics for the treatment of disease and infections.

2.1.1 Concerning the spread of bacteria

Within healthcare, where the problems with antibiotic resistance are the greatest, spread of resistant bacteria has long been an observed problem. Resistant bacteria, like other bacteria, are spread by persons and personnel within healthcare environments as a consequence of e.g. inadequate hygiene procedures. But also technical equipment, materials, wash basins and drainage has been shown to contribute to the spread of antibiotic resistant bacteria.[3]

Resistant bacteria are spread across national borders by travel, commerce and the transportation of animals and foodstuffs. The increasing travel and trade of recent decades has thereby also contributed to making the problem of resistance greater. In this context, the growth in global medical tourism is a specific challenge.[4]

The bacteria we all carry ends up in the environment we have around us, for instance through our drainage outfall, sludge from wastewater purification plants and fertiliser from animal husbandry. This means that the outdoor environment may function as a reservoir for antibiotic resistance.[5]

Resistant intestinal bacteria of human origin, for example, have been found in birds that breed on the Siberian tundra, some 1,000 km from the nearest settlement.[6] What the existence of resistant bacteria in the environment implies is an under researched area.[7]

Antibiotic resistant bacteria may be spread to animals and humans both by way of drinking water that has not been sufficiently purified and by way of other foodstuffs.[8] There is a need, however, for further knowledge concerning the extent that this happens today and its significance for public health.

2.1.2 On the situation in Sweden and the rest of the world

The occurrence of resistant bacteria varies greatly in different parts of the world as can be said for data collection and monitoring systems. There is insufficient data to be able to create a complete picture or update concerning the development of resistance. Nevertheless, there is no doubt that antibiotic resistance is a growing global problem. The share of different bacteria that has developed multidrug resistance is increasing. The number of difficult-to-treat resistant bacterial infections e.g. resistant tuberculosis, is now on the increase. In step with the development there is also a reduction in functioning antibiotic preparations.[9]

There is a clear link between the misuse of antibiotics and the occurrence of resistance. In those countries where more antibiotics are consumed the resistance is also more serious. Antibiotic resistance is generally more far-reaching in Asia, above all in India and China. In Europe, on the other hand, resistance is more common and more serious as a problem in the southern European countries compared with those in northern Europe.[10]

In the EU, about 25 000 persons die each year as a result of having fallen ill of infections caused by resistant bacteria. Annually, about 400 000 persons fall ill on account of infections caused by antibiotic resistant bacteria (figures for 2007).[11]

In Sweden, the occurrence of resistant bacteria is more limited compared with large parts of the rest of the world. Many years of work to limit the use of antibiotics both within medical care and within animal husbandry have contributed to this situation.[12] Sweden has had a driving role in the global work against antibiotic resistance, for example within the WHO and the EU.[13] Sweden, however, is influenced by the situation in the outside world and antibiotic resistance is growing here too, partly as a result of travel.

It is not fully established to what extent foodstuffs contribute to the spreading of antibiotic resistant bacteria.[14] In Sweden, above all, chicken meat has been shown to contain resistant bacteria. In tests on chicken meat, resistant intestinal bacteria occurred in 95 per cent of chicken meat from South America and in 44 per cent of chicken meat from Sweden.[15]

2.2 Continued development of antibiotic resistance?

The understanding of the serious nature of the problem of antibiotic resistance is growing and the preventive work is now starting to pick up speed around the world. At the same time the resistance situation is deteriorating continuously. However, it is difficult to assess the future development of antibiotic resistance owing to the many macro and micro level processes (and the interaction between them) that affects the resistance.

2.2.1 How to work against widespread antibiotic resistance

Successful preventive work is decisive in determining whether it will be possible to check the development of antibiotic resistance. The foundation for preventing antibiotic resistance rests on two principles: a more rational use of antibiotics and preventing the spreading of resistant bacteria.[16]

The preventive work is under development in many areas of the world. Sweden is relatively far ahead in this work which is based partly on *Strama*, a network of physicians and other experts that was formed in 1995. Where animals are concerned, there is a corresponding network since 2005, Strama VL (veterinary and foodstuffs). There is also a national strategy and the National Board of Health and Welfare has the task, in cooperation with the Swedish Board of Agriculture, of carrying out a national co-ordination function and draw up a cross-sector action plan. Given the mobility of the bacteria across national borders, the development of preventive work against resistance in all countries is of decisive importance for the future development of antibiotic resistance, both globally and in Sweden.

Rational use of antibiotics

A more rational use of antibiotics is of the greatest importance for checking the development of resistance. The use of antibiotics,

both for animals and people, needs to be more responsible and global strategies needs to be implemented. This means not using antibiotics unnecessarily and using the right antibiotic at the right time, with the right dose, dosing interval and treatment period.[17]

The awareness of the problem is increasing. This should serve to increase the preconditions for introducing restrictions around the prescription and use of antibiotics around the world. In many countries, and at an international level, different projects, campaigns, strategy work and so on are being implemented, all intended to reduce the use of antibiotics. These are directed both at the medical profession and at the general public. In many countries, the use or the prescription of antibiotics for humans has also been diminishing for several years.[18]

In Sweden, the total use of antibiotics for people has declined by 15 per cent since 1995.[19] This reduction can be increased. The Swedish government has set up a goal to lower the prescription of antibiotics in Sweden by just over one third compared with 2010.[20] The sale of antibiotics for use on animals is also decreasing in Sweden.[21]

Globally, however, before we are probably far from achieving a rational use of antibiotics which can check the development of resistance is in place. In many countries antibiotics are sold without prescription and antibiotics are also used as growth-promoting substances in food-producing animals. In the USA, for example, more than 70 per cent of all antibiotics are used in animal husbandry.[22]

A more rational use of antibiotics would also be promoted with the development of rapid diagnostic methods so that correct diagnoses can be made and antibiotics not used unnecessarily. Quicker and improved diagnosis would also facilitate the correct use of antibiotics, in the right dose and during the right time.[23] This applies to both human and veterinary medicine.

Measures to prevent the spread of bacteria

Reduced infectivity (contagion) which implies fewer infections would check the development of resistance through reducing the need to use antibiotics in the first place.

An increased awareness amongst the general public of issues such as contagion, hand hygiene and food hygiene are a basic component in the work of preventing the spread of antibiotic resistance. This awareness could increase further and thereby contribute to impeding the development and spreading of resistance.

Within the medical care sector, work has long been undertaken to reduce the spread of care-related infections. This includes, for example, that nursing staff have good knowledge in care hygiene, methods of disinfection and sterilisation, procedures for taking samples and contact tracing, design of premises and equipment as well as procedures for how patients and personnel respectively carrying resistant bacteria need to be looked after.[24] The infection prevention work can be further developed, however. According to certain studies, roughly every tenth hospital patient received antibiotics as a result of a medical care related infection. Of these infections at least 20 per cent could be avoided through maintaining a good care hygiene standard.[25]

Within animal husbandry (stock raising) and veterinary medicine, a satisfactory general animal health is a really important preventive measure. This is achieved through good management, illness prevention and infectious disease control.[26] Even though Sweden has come relatively far in this area too, the preventive work can be further developed. Recently, attention has been called to the need to acquire more knowledge of the field.[27] By continuing to develop measures for limiting the spread of bacteria amongst animals, the development of antibiotic resistance could possibly be further checked. This may, for example, involve the vaccination and isolation of farms with infectious diseases and, where necessary, the putting down of the entire animal stock.

Where the spread of resistant bacteria in the environment is concerned, this could be checked through using properly developed techniques for waste processing and for the purification of wastewater.[28]

Measures to limit the spread of bacteria may thus be developed further within many areas which could serve to impede the development of resistance. Such measures, however, are associated with extensive costs.

2.2.2 Developments in society at large

Besides the work described in the preceding section, the broader development of society will indirectly play a significant role in the emergence and spread of antibiotic resistance. In this study, focus is on developments in health and travel, migration and trade.

Development of health

The need of antibiotics is dependent on the evolution of human health. This can be linked to a series of different factors. An ageing population in large parts of the world may increase the need for antibiotics since older persons are more sensitive to infections. Climatic changes may both increase and decrease the need for antibiotics. For example, higher temperatures leads to bacterial growth in food, but milder winters mean fewer bronchial infections. A major influenza outbreak or pandemic could also increase the need for antibiotics since bacterial complications require treatment.[29]

However, medical developments can lessen the need for antibiotics through creating a generally improved public health with increased robustness against infections. Medical progress may, at the same time, increase the need for antibiotics; for example, certain cancer treatments entail an increased risk of infections.[30]

Public health, the transmission of diseases, and the occurrence of infections are also linked with the socioeconomic and demographic trends in society. Insufficient access to drinking water, overcrowded living conditions in urban areas, inadequate sanitary and hygienic facilities, inadequate water supply and wastewater treatment systems and substandard waste management all affect human health and make them more exposed to the spread of disease. Access to antibiotics without prescription may lead to mistreatment in many developing countries. Moreover, the antibiotics that are sold in many developing countries are of inferior quality.[31] So long as these conditions remain a continued growth in resistance to antibiotics is favoured.

The public's trust in public institutions and their agents as well as the readiness to follow recommendations can also play part in resistance development. For example, the readiness to follow vaccination recommendations plays a large role in public health, the need to use antibiotics and thereby the development of resistance.[32]

Travel, migration and trade

Today's globalised world where goods, animals, foodstuffs and people move across national borders contribute to the spread of bacteria. Developments where travel, migration and trade are concerned will therefore be significant for the development of resistance. There are few signs today that travel and trade across frontiers are likely to diminish in scope.

It is very common for foreign travellers to bring resistant bacteria home with them. A study of some fifty or so individuals who had visited Egypt, Thailand and India showed that a third carried resistant bacteria on their homecoming.[33] Another study which investigated individuals who sought care for stomach problems after a foreign visit showed that 3 per cent of those who travelled in Europe, 50 per cent of those who travelled in the Middle East and 80 per cent of those who visited India carried antibiotic resistant bacteria.[34]

2.2.3 Development of new antibiotics

To develop new antibiotics has been shown to be very difficult. Between the years 1928 and 1987 new classes of antibiotics were discovered at regular intervals. But since then no new antibiotics have been discovered. The new antibiotic treatments that since has been released on the market have been developed from discoveries made before 1988 or are variants of existing classes. To develop new antibiotics is not only scientifically challenging; there are also limited economic incentives for the pharmaceutical industry to carry out research in this area. One of the reasons for this is that there are many competing and cheap antibiotics on the market. Unlike many other pharmaceutical products, for example to treat chronic illnesses such as diabetes, antibiotics are only used for a short period and therefore do not yield similar financial returns.[35] A possible new antibiotic product risks rapidly become ineffective, moreover, in a world where we frequently misuse antibiotics.

2.3 Future dependence on antibiotics

It is not possible to analyse the significance of more extensive antibiotic resistance for societal security without also having taken into consideration the capacity for society to manage without antibiotics. So what are the alternatives?

It is evident that antibiotics have played a very large role for the progress that has been made in the field of public health during the last 70 years. However, a world without antibiotics would not necessarily mean a return to the same situation as before antibiotics were discovered. Access to clean water, good sanitary conditions and medical care, improved socioeconomic conditions and increased knowledge about hygiene are factors, besides the availability of antibiotics, which have contributed to better public health. A continued development in these areas contributes to lessening the need for antibiotics.

Today's medical care is certainly wholly dependent on antibiotics in many of the treatments, operations and measures that are undertaken. However, with new techniques and medical progress it should be possible to develop new ways of preventing infections and alternative treatments could be developed. For example, there is research surrounding antimicrobial materials which may be used for e.g. hospital clothing and dressings, new vaccines against tuberculosis and the use of nanotechnology to neutralise bacteria.[36] Sometimes other microbiological medicines are highlighted as conceivable alternatives. One of the most recurrent in this context is bacteriophage (a virus that attacks bacteria).[37]

There are, however, no guarantees that the research will generate alternatives to antibiotics in time. In the report *Global Risks 2013,* there is a warning against over-reliance on scientific advances in this area.[38]

A society with insufficient access to functioning antibiotics might also be able to handle this situation through more powerful measures to limit the spread of bacteria. This leads on to the next chapter and the analysis presented there concerning what a more far-reaching antibiotic resistance might have in terms of consequences.

Consequences for societal security

3. Consequences for societal security

In the previous chapter, the problem of antibiotic resistance was described and different factors that affect future developments were discussed. This chapter takes as its starting point a possible future scenario, where antibiotic resistance in Sweden and the rest of the world is significantly more extensive than today.

3.1 Scenario – a more extensive antibiotic resistance

Scenario – A society with more widespread antibiotic resistance

In year X, the development and spread of antibiotic-resistant bacteria have gone so far that there are only a few effective antibiotics left, remaining since a very large share of the bacteria are multidrug resistant. The few antibiotics that still have a certain effect are subject to wide-ranging restrictions concerning when and how they may be used. The research has still failed to generate any satisfactory alternative to antibiotics. This means that infections must be fought against using measures that prevent the spread of bacteria, e.g. hygiene, disinfection, isolation, sample taking and decontamination.

3.2 Consequences for values to be protected

Work to enhance societal security shall contribute to protecting certain values underpinning modern society. Within MSB, and on the basis of the goals set by the Swedish Government, these values have been defined. The values to be protected are as follows:

- People's life and health.
- Societal functions.
- Democracy, legal certainty and human freedoms and rights.
- Environment and economic values.
- National sovereignity.[39]

In the following, we set out the arguments concerning what a more far-reaching antibiotic resistance could mean for each and every one of these five values.

3.2.1 People's life and health

People's life and health is presumably the value which is affected most directly by the development described in the scenario.

Effective antibiotics are a prerequisite for modern medical care. Without antibiotics the treatments of both common and uncommon infections are impeded within both in-patient and out-patient medical care. In disaster medicine, for example in connection with major accidents, antibiotics are required to treat the serious infections (e.g. blood poisoning) that otherwise may arise in the event of serious physical and abdominal injuries. In the case of flue outbreaks and pandemics antibiotics are required to treat bacterial complications that occur, for example pulmonary infections.

With inadequate access to effective antibiotics and without satisfactory alternative treatments, infections will arise and spread more easily. Infections that nowadays can be cured in one or two weeks may also become drawn out and more often life-threatening.

One scenario, in this context, affecting the capacity of medical care to prevent and treat infections would imply that many more people will die of infections. People's health will also be affected through longer periods of sickness. Prostheses and other treatments not deemed to be decisive for life-saving causes may, in certain cases, be avoided altogether owing to the risk of infection, an outcome which will also affect people's health and well-being. The number of vulnerable individuals in society can be expected to increase. Mental health also amongst people may be affected through e.g. anxiety and increased suffering.

People's life and health could be affected more indirectly in the scenario described in this study since a more far-reaching antibiotic resistance may give rise to disturbance in societal functions. For example, interruptions may arise in pharmaceutical and food supplies while emergency life-saving inputs carried out by the ambulance, police and rescue services may be subject to extensive restrictions to prevent the spread of infections.

Equally, it is possible that the enforced hygiene measures may have certain positive effects on life and health. During the influenza pandemic A(H1N1) for example, the number of sick children in child-care declined owing to the new and enhanced hygiene procedures.[40]

3.2.2 Societal functions

The value defined as societal functions, encompasses the functionality and continuity of those factors that strongly affect the day-to-day life of individuals, companies and other organisations (physical and legal persons).[41]

In order to maintain this functionality certain functions and activities are of special importance; these can be characterised as societally essential.[42] Societally essential activities are defined as a societal function of such importance that the loss of it, or a serious disturbance in the function, would imply a great risk or danger for the population's life and health, society's proper functioning or society's fundamental values. A societal function, the task of which is to manage an ongoing serious event or crisis so that the damaging effects are as limited as possible, is also a societally essential activity.[43]

Exactly which functions are societally essential may vary depending on the situation, as well as the development of society. To maintain these societally essential functions there are different important activities at different levels. For example, within the medical care sector, emergency medical care is a societally essential function that is maintained by a number of activities, for instance a hospital. The loss of, or interruptions in, these activities and functions have consequences for the value to be protected i.e. societal functions.

Medical care

The societally essential functions that are probably affected most by the scenario in this study are to be found within medical care. The maintenance of what could be regarded as an acceptable functionality within the medical care sector depends on how rapidly the development of antibiotic resistance takes place, and to what extent medical care can be adapted to the new situation.

Significantly more extensive measures for medical care hygiene and the limitation of infectivity would become necessary in the current scenario. Expanded procedures in respect to sample taking, contact tracing, hygiene, and disinfection and so on would probably require more resources in the form of e.g. personnel. Ambulance care may come to constitute a special risk environment with crowded spaces and shortage of time for cleaning and disinfection between emergency callouts. More far-reaching demands for disin-

fection and other measures could lead to available ambulance resources decreasing.

Medical care, to a greater extent than at present, could be forced to use treatments which are longer, more risky and more awkward – and more resource-intensive. If more people become ill, and during longer periods, medical care would also be affected by the increased workload this would imply. All in all, this may affect medical care's functionality.

Pharmaceutical supply
In a scenario where the number of still effective antibiotics is very limited, there may arise a situation where the production of these does not correspond to the high demand. The effective functioning of the pharmaceutical supply could be affected. There are already today examples of pharmaceutical supply in Sweden where a certain antibiotic preparation, on several occasions, has run out owing to available stocks being too small and problems in procuring the raw material required for production.[44]

Care of children, the disabled and elderly people
Care of children, the disabled and elderly are risk environments when it comes to the spread of infections. Children and elderly persons are, moreover, more vulnerable and consume more antibiotics than other groups.[45]

Within the care sector work is carried out in different ways to limit the spread of infection, both among those persons being looked after and amongst the personnel. One example is through increased knowledge and developed hygiene procedures.[46] With one scenario implying a more far-reaching antibiotic resistance, the measures to prevent the spread of bacteria will be even more essential within these activities. Hygiene and cleaning procedures would need to be developed further as well as procedures surrounding carriers and illnesses. It is possible that there would be a need to close units in the case of outbreak of infection. In such a case this would give rise to certain interruptions in societally essential functions.

Foodstuffs
Foodstuffs such as dairy products, meat, fish, vegetables, fruit and drinking water can all contribute to spreading bacteria to animals and people. A more far-reaching antibiotic resistance could mean more antibiotic resistant bacteria in foodstuffs.

In this situation, it may be even more important that the food does not spread bacteria to the consumers or to those persons who work within food production. This means that infectivity prevention restrictions need to be developed.

Different restrictions may need to be developed for different stages in food production. Once at the preparation phase, hygiene and correct preparation procedures will be essential. This naturally entails that the costs associated with food management may increase. Restrictions of different types may also cause certain disturbances in the food supply logistics.

Since food production is closely associated with animal life and health measures to prevent infections needs to include safeguarding good animal health in the food production chain. Livestock rearing would need to work further with preventive measures. It might also be necessary to set higher demands/standards on trading with animals.

The scenario in this study may imply more animals dying from infections, but also that animals in food production may come to be regarded as a source of antibiotic resistant bacteria. In such a case the preconditions for basing food production on animals may deteriorate, and thereby fewer animals are reared. In more extreme situations, entire livestock herds may need to be slaughtered to prevent the spread of bacteria. This in overall terms could lead to interruptions in the food supply where meat and dairy production are concerned.

Certain disturbances in the food retail sector could also arise if the import of foods, as a consequence of more far-reaching antibiotic resistance, was subject to more restrictions. At the same time the demand for Swedish food could thereby increase.

Drinking water supply
In a scenario with more extensive antibiotic resistance it is possible that demands on water purification would increase. On the one hand, the water leaving the drinking water plants needs to have been sufficiently purified. The piping systems also need to maintain a sufficiently high quality so that the water is not contaminated on the way to the consumers. To the extent that this cannot be achieved, disturbances in the drinking water supply may arise.

It cannot be excluded that in a situation resembling the scenario, owing to anxiety about antibiotic resistant bacteria, it is decided not to use all the water resources (water collection sources) that are used today. The inadequate quality of unfiltered water may lead to the unfiltered water supply sources becoming more limited in number.

Wastewater management
In a scenario with more far-reaching antibiotic resistance, wastewater management has a role in the work of preventing the emergence and spread of resistant bacteria into the environment. Discharges of antibiotic residues, antibiotic resistant bacteria and resistant genes may all contribute to antibiotic resistance arising and being spread in the environment. Wastewater purification plants can reduce the great majority of the bacteria.

In the scenario it is, nevertheless, conceivable that one might want to build up several purification barriers to clean the water of resistance inducing substances. One important measure to diminish the emergence of bacterial resistance is to limit the discharges of drug residues.

Where the separation of medicines/drugs from antibiotics is to be undertaken, then this will produce more sludge, which must be taken care of in a safe way.[47] The handling of this sludge may also entail increased costs. One alternative is that activities where a large volume of drugs are dispersed in the outflow, example in the case of medical care establishments, have their own, more effective purification processes before the wastewater is fed into the ordinary systems.

To the extent that it is not possible to adjust the wastewater handling in such a manner, it is possible that certain disturbances in this socially essential function may in fact arise.

Rescue services, police and military defence
The civil protection and security sector encompass several societally essential functions, for example the rescue services, the police and military defence. These functions may be affected by the scenario described in this study owing to the fact that more far-reaching hygiene procedures and restrictions may be required with the object of preventing the spread of infection.

Personnel within, for example, the rescue, police and military services can be more exposed to health risks in the event of a more wide-ranging antibiotic resistance. A certain risk for spreading of bacteria may be found in the working environment in these activities. Personnel who share a gym, changing room, shower room, certain equipment and so on can transfer bacteria and infections between one another. There is also a certain risk for the spread of bacteria through work assignments. For example, personnel within the emergency and rescue services and the police may be more exposed to infections since they have close contact with people; sometimes they need to carry out emergency life saving inputs such as cardiopulmonary resuscitation (CPR). It is not uncommon that the rescue services arrive first at the site of an accident, and thereby are the first to administer care to injured people.

There are studies that point out that already today there may be a spread of resistant bacteria within the rescue services. In the USA, personnel within the rescue services, firemen and ambulance personnel have been shown to be carriers of certain antibiotic resistant bacteria more often than the average person. To reduce the infectivity rescue personnel are encouraged not to share equipment.[48]

In the case of international disaster relief, the personnel can be more exposed to certain bacteria and infections. In a scenario with more far-ranging antibiotic resistance these infections may then be hard to treat in the absence of effective antibiotics. Since the personnel during foreign missions often live and operate under very basic conditions the infection risk is increased.

The scenario may therefore imply certain health risks for personnel within the emergency and rescue service, the police and military. Hygiene procedures and certain protective equipment such as gloves and safety eyewear are already used today by the emergency and rescue services. Vaccination against hepatitis is also offered within certain emergency and rescue services. In a scenario where there is more extensive antibiotic resistance there is a need to develop even stricter hygiene procedures. Even the disinfection of materials and means of transport can become more important.

A more far-reaching antibiotic resistance would also affect the character of the particular assignment and the performance of the personnel involved. Different kinds of restriction imposed on how to act during emergencies, and what one may - and may not - do could well be relevant here. Emergency, life-saving contributions from the police and rescue services could be surrounded by wide-ranging infectivity prevention restrictions. More time-consuming procedures may well need to be introduced. A more extensive antibiotic resistance could, in this way, have consequences for the civil protection and security sector.

General observations concerning consequences for societally essential functions

At a general level, the societal functions could be affected indirectly by a more extensive antibiotic resistance through a more significant personnel reduction in those activities that constitute societally essential functions. With inadequate access to effective antibiotics the personnel may need to stay at home more often, and for longer periods, due to own sickness or to care for those nearest and dearest to them. It is uncertain if antibiotic resistance could, in this way, generate such extensive absence from work that there would serious disturbances or interruptions in societally essential functions would occur. Antibiotic resistance in combination with an influenza pandemic could possibly have this effect.

Risks of being affected by difficult to treat infections at work could make it more difficult to recruit and retain personnel for certain societally essential functions and activities. Particularly exposed are personnel within medical care as well as care of children, the disabled and elderly. There could occur also recruitment difficulties within protection and safety, e.g. the police, the fire service and

personnel for international disaster relief. However, even here it is hard to imagine that these recruitment difficulties would be so great that societal functions would be affected to any greater extent.

On the other hand, societal functions could be affected seriously where more far-reaching antibiotic resistance implies large financial outlays and has consequences for the value to be protected in the form of the environment and economic values. If savings and cuts within societally essential activities become necessary, this could lead to major vulnerabilities and increased risk for disturbances in, and stoppages of, certain functions.

3.2.3 Democracy, legal certainty and human freedoms and rights

In the scenario described in this study, the antibiotics that still function properly are subject to far-reaching restrictions in respect of when and how they may be used. This circumstance means that there is a risk of corruption, illegal trade, smuggling and development of organised crime. Such a development could affect society's administrative ability at different levels, and people's belief in the rule of law.

We also expect that the antibiotic treatment shall be safe. Where the health service must set stricter priorities for those who receive antibiotic treatment and other medical care this may also strain public trust and confidence. The experience of unequal treatment may lead to mistrust towards the health service. However, the public may also lose trust in other public agencies if they fail to deliver the services expected, for example the police and rescue services.

If one lives in a society where one needs to protect oneself and those closest more actively against infection it is also conceivable that anxiety, fear and mistrust between people will increase. Many people may start avoiding public environments and contact with unknown people out of fear of infection. The reliance on society may be negatively affected which can have consequences for people's involvement in e.g. voluntary organisations. Possibly people's readiness to help in the event of accidents and acute cases of disease may also be negatively affected.

International relations may also be affected by a situation which demands far-reaching, global cooperation surrounding antibiotic resistance. Disagreements between states may arise where the distribution of effective antibiotics is perceived to be unjust or where all fail to follow agreed restrictions concerning their use. Tensions may also arise if countries introduce stricter controls and limitations on international trade, travel and migration. At the same time, the necessity of collaborating internationally can also serve to promote good international relations and exchange. Sweden's international reputation may be favoured by our good starting point and our experience of undertaking measures to prevent antibiotic resistance.

3.2.4 Environment and economic values

Environment

A more far-reaching antibiotic resistance according to this scenario would probably mean more resistant bacteria amongst wild animals and in nature, for example in watercourses. This would probably not have any direct effect on the environment protection value, since antibiotics are not used against bacteria in the environment or with wild animals. The existence of resistant bacteria could, however, affect our approach to nature and wild animals. An increased risk for resistant Vibrio infection could, for example, mean that people refrain from bathing in lakes. There may also be a necessity for limitations on how pets and animals within food production are present in nature.

On the other hand, should pets or animals used for food production be indicated as a source of infection and major changes occur in animal husbandry, or in the more extreme case – extensive destruction of animals becomes necessary – then this could possibly constitute a threat to biological diversity in Sweden.

In this scenario the environment could be affected by the measures required to limit the spread of bacteria. If the purification of wastewater and water needs to be carried out more effectively then this can have a positive effect on aquatic environments. However, if natural fertiliser needs to be replaced with phosphorous-based nutrients within plant cultivation (crop production) then this may affect the environment negatively.

Economic values

A more widespread antibiotic resistance may have major economic consequences. Several studies show increased costs for care of patients with resistant bacteria. Frequently, the costs increase by up to about 30 per cent.[49] The methods for calculating the costs vary and examples of factors that may be included are extra hospital days, more expensive medicines, more sample taking, costs of intensive care, costs for limiting or managing infectivity as well as loss of productivity on the part of those fallen ill. The Swedish Public Health Agency has been given the task by the government of developing a model for health economic calculations in respect of antibiotic resistance.[50]

Economic calculations have shown that present day costs within the EU for antibiotic resistance amount to about € 1.5 billion, whereby extra medical care costs amount to € 900 million and productivity loss for € 600 million of the total cost.[51] A more widespread antibiotic resistance as described in the scenario would naturally drive up these costs even further. Medical services (healthcare) could need to be run in another way with more hospital beds, single rooms, more staff etc.

In addition to the costs for medical care and for production losses, a more widespread antibiotic resistance would likely also cause large costs for infectivity limiting measures in society as a whole. Expanded hygiene procedures within care may demand more personnel resources. Large investments may need to be undertaken in water and wastewater systems. Measures to limit the spread of bacteria within livestock production and foodstuff handling may cause considerable economic consequences for both the individual farmer and for the foodstuff sector as a whole.

The costs to society of a more extensive antibiotic resistance could thus become very large in scale, both in terms of costs for handling/managing the resistance and in terms of productivity loss. The consequences for the economy of different countries could well be very significant.[52] Public sector budgets could end up in imbalance as a result of rocketing healthcare costs. Stretched economies may have consequences globally in terms of trade and economic growth. Reduced trade to limit the spread of bacteria may also negatively affect the world economy.

3.2.5 National sovereignty

In the scenario, it is not certain that the few antibiotics that are still effective can be produced on a sufficient scale and nor is it certain that the production will take place in Sweden or in the EU. The nation's access to effective antibiotics could therefore prove to be insufficient.

The food supply, in this scenario, in overall terms is affected by more far-reaching antibiotic resistance; but the situation would need to be extreme indeed for one to be able to speak about the nation's supply of food being threatened. Such a situation could possibly arise if it becomes necessary to limit the import of food, if the widespread slaughter of livestock for food production becomes necessary and resistant bacteria is spread by fruit and vegetables.

Concluding remarks

4. Concluding remarks

Antibiotic resistance already today is a very large problem confronting Sweden and the rest of the world. The challenge facing society with the development of antibiotic resistance is increasingly highlighted, and resistance prevention work is being undertaken in many different contexts. However, it is very uncertain if the resistance development can be checked sufficiently for medical research to manage to produce new antibiotics or satisfactory alternative medical treatments in time.

4.1 Concluding discussion concerning consequences

In accordance with the mandate given MSB to analyse especially serious vulnerabilities, threats and risks, MSB in this study has investigated what a more far-reaching antibiotic resistance could entail for societal security. The analysis is based on a possible scenario where antibiotic resistance is significantly more far-reaching than it is today and has attempted to answer the following question: which consequences could a more extensive antibiotic resistance entail for the national values (core social values)?

The discussion about the consequences is not merely limited to that which is most probable. Instead, there is a discussion of many different possible consequences that, in the longer term, could affect societal security. This means that this study can be used as background material to assist weighing up the risks or the lurking threats of antibiotic resistance, on the basis of a societal security perspective, and help to answer the question: how bad can things get?

A more extensive antibiotic resistance could have consequences for those whom the antibiotics are intended to protect. The value which is assessed to be affected most directly by antibiotic resistance is naturally life and health, but also societal functions, democracy, legal certainty and human rights and freedoms, the environment and economic values and also – to a more limited extent –national sovereignty could be affected.

Life and health are threatened in the case of a development that implies more far-reaching antibiotic resistance. Infections will emerge and spread more easily, be more difficult to treat and increasingly often life threatening. Societal functions can be affected since different measures taken to limit the spread of bacteria in socially essential activities may cause disturbances. Democracy, legal certainty and human rights and freedoms may be affected, for example, through confidence in society's institutions decreasing. The environment and economic values can be affected, for example, through the cost to society of a more extensive antibiotic resistance becoming very considerable.

The rate of resistance development pays a large role in determining the conceivable scale of these consequences. With a more rapid evolution the society has shorter time to adapt itself and to introduce the hygiene restrictions and other measures that may become necessary. The analysis in Chapter 3 also makes clear that the different values are related and interact with one another. When a value is affected or threatened, it may have consequences also for the other core values.

4.2 Additional reflections

It is possible, moreover, to add to all the consequences discussed in the previous section certain reflections concerning how societal security is affected by antibiotic resistance.

It is possible that society, in the case of a continued resistance development, may arrive at a breaking point. At this conceivable breaking point, the antibiotic resistant bacteria are so widely spread that it is no longer worth the effort, by all means possible, of trying to limit the continued spread of the resistance. This could occur, for example, if a majority of all people came to be carriers of the ESBL-producing bacteria. It may also occur in the case of a sneaking acceptance of, and habituation to, a situation where the healthcare services can no longer self-evidently treat infections.

Antibiotic resistance is a threat that may be said to have certain similarities with that of climatic change. The changes take place gradually and the effects of countering antibiotic resistance are

uncertain and costly. In Sweden antibiotic resistance is managed primarily with preventive measures, an approach that also paved the way for today's relatively good position.

Considering climate change, the work is carried out both preventively and managing the adjustment of society to the new climate. One question that follows is whether the society also needs to work more with the management of, and adaptation to, a situation with more widespread antibiotic resistance. (The preventive work linked to antibiotic resistance can, of course, also lead to adjustment to the situation to a large extent.) In other countries, some measures to handle the situation are used that seems distant in Sweden. In Greece, where there is a major problem of antibiotic resistance, patients that *do not* bear resistant bacteria are isolated on admission to hospital.[53] If there is a clear risk that antibiotics, despite our preventive work, are losing their effectiveness how then do we best prepare ourselves for this?

At a more general level, this study illuminates the importance of the general public having trust in each other, the society in which they live and the public sector. To be able to prevent and manage antibiotic resistance it will probably be necessary that the individual will have to change certain behaviours and introduce new procedures. Certain medical services which were previously seen as a matter of course, such as a prosthesis operation, will perhaps no longer be seen as such. How the public sector (healthcare services) handles this issue will affect public confidence, in the same time as public trust and confidence will shape how well the healthcare service handles the issue.

To summarise, this study of antibiotic resistance shows the problem's complexity and the importance of adopting a proactive approach. This means that one follows the development of resistance carefully, that one is ready for a more serious development and, moreover, that one has an idea of when it may be necessary to move from a mainly preventive strategy to one of management and adjustment. This work also needs to be carried out on the basis of wide-ranging cooperation, both nationally and internationally.

4.3 How MSB can approach antibiotic resistance

MSB has the following mandate: "in cooperation with other agencies and authorities, municipalities, county councils, organisations and companies to identify and analyse such vulnerabilities, threats and risks to society that may be considered to be especially serious. The Agency, moreover, together with these responsible agencies and authorities shall carry out the strategic planning of measures that should be adopted. The Agency shall evaluate, compile and report the results of the work for the Swedish government."

A situation that implies more widespread antibiotic resistance would represent such a serious development, and a situation which MSB needs to analyse and follow. At the same time, one needs to be aware that the situation does not need to be fully as serious as the scenario in this study. The scenario is only a description of what could possibly happen, and does not include any probability assessment as to how likely it is to happen. Moreover, there is no assessment either as to whether it is more likely than any other scenario.

However, from the preparedness perspective there are grounds to be aware that there *may* occur a development that reminds of the scenario. There is thereby also good reason to investigate what, in such circumstances, such a development would have by way of consequences. This study may be seen as supporting information within this frame of reference.

Antibiotic resistance is a cross-sector issue that affects all of society. It is therefore of great importance that relevant interested parties and operating bodies in civic protection and public safety (civil contingencies) approach antibiotic resistance in a deliberate way and analyse how their activities are affected by impaired resistance. The cross-sector nature of antibiotic resistance makes this a question that MSB must adopt a position on from an emergency preparedness viewpoint. This is so since the Agency has the mandate, from a strategic national level, of monitoring and evaluating emergency preparedness.

From an emergency preparedness perspective, a more extensive antibiotic resistance may be seen as a complicating factor in connection with events that imply an outcome with large loss of life and injuries or an outbreak of widespread disease. The medical

services will possibly not have the same capacity to treat major physical injuries in connection with large-scale accidents or bacterial complications that follow a pandemic.

Within the framework of the work on a national risk assessment by the MSB a scenario dealing with antibiotic resistance will be analysed during 2014-15.[54]

Finally, for MSB, it is also essential to continue monitoring how the development of antibiotic resistance can affect the Agency's own areas of responsibility, such as municipal rescue services and international emergency relief. In a society without the capability of treating infections, there may be a need to build up more knowledge and more procedures and routines to prevent the spread of infection.

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