



Portrait of the National Research Programme (NRP 72)

# Antimicrobial Resistance



SWISS NATIONAL SCIENCE FOUNDATION



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### **What is an NRP?**

National Research Programmes (NRP) provide scientifically substantiated solutions to urgent problems of national significance. They are approved by the Federal Council, last from 4 to 5 years and are funded with CHF 5 to 20 million. NRPs are problem-oriented; inter- and transdisciplinary; dedicated to achieving a defined, overall goal through coordination of individual research projects and groups and focused on the knowledge transfer of the results.

## A call for innovation and decisive action. Science take note.

Antibiotic drugs are indispensable to modern medicine. But their effectiveness is under threat: more and more pathogens are becoming resistant to one or several antibiotics, and increasingly even to all available antibiotics. If this trend continues, we run the risk of not being able to treat bacterial infections in the foreseeable future. This would have grave consequences for patients and for society at large.

It is time to act. The political will to do so is there. In September 2016, the UN General Assembly declared antibiotic resistance to be a priority.

Many countries are planning measures or have already implemented them. Switzerland has launched its National Strategy on Antibiotic Resistance (StAR), which includes comprehensive efforts in the areas of human and animal medicine, agriculture and the environment.

Yet despite this commitment to act, in certain areas we lack the knowledge or appropriate means to effectively fight antimicrobial resistance. Consequently, although it is clear that we must reduce the use of antibiotics, the question is how we can achieve the necessary

behavioural changes in a way that is politically, socially and economically acceptable.

In addition, new drugs are urgently needed against resistant organisms. We also require faster diagnostic tools that enable targeted treatment of infections. Unfortunately, too little has been done in both these areas in recent years.

Finally, we need better understanding of the processes that lead to the development and spread of resistance. Such knowledge is a prerequisite for being able to selectively prevent the transfer of resistance genes between bacteria and across different ecosystems.

In view of these challenges and the persistent lack of approaches to solving them, science has a pivotal role to play. It must supply the knowledge that is critical to overcoming antimicrobial

resistance. NRP 72 aims to contribute to this goal. Together, practitioners of clinical and veterinary medicine, biologists and environmental scientists are tackling the many tasks associated with developing practical solution approaches in all the fields.

We realise that this is a very ambitious goal. The problem of resistance demands innovation and decisive action from us as researchers. Both require a comprehensive approach given the complexity of the problem. This is the “one health” approach. It recognises that the development and spread of antimicrobial resistance in humans, animals and the environment must be investigated across the board. Consequently, we are combining our forces and working together on projects in an interdisciplinary manner.

However, we do not wish to exchange the knowledge gained only among scientists. Rather, it should reach anyone involved in promoting the fight against antimicrobial resistance in practice. This includes those charged with implementing StAR as well as stakeholders in politics, business, public health and many other areas.

I look forward to an active dialogue with all these partners, and to collaborating with so many excellent researchers, all of whom share a single goal: securing the future of antibiotics as a key pillar of modern medicine.



A handwritten signature in black ink, consisting of a stylized 'C' followed by a horizontal line and a small loop.

**Prof. Christoph Dehio**  
President of the Steering Committee  
NRP 72

## A comprehensive research approach to a multifaceted problem

**The National Research Programme “Antimicrobial Resistance” (NRP 72) seeks new solutions to overcoming the problem of antibiotic resistance. To this end, it brings together research groups from different disciplines who are investigating various aspects of resistance.**

Since the end of the last century, the world has faced a dramatic development: the increasing spread of antimicrobial resistance. More and more frequently, clinicians must deal with serious infections caused by pathogens that are resistant to all the antibacterial drugs available on the market.

### **Focus on applied research**

To counter this development, the Swiss National Science Foundation (SNSF)

launched the National Research Programme “Antimicrobial Resistance” (NRP 72) on behalf of the Federal Council. This is the second NRP devoted to this topic. The first, NRP 49, was conducted over the period 2001–2006. Its pioneering achievements led to the creation of the Swiss Centre for Antibiotic Resistance (Anresis), which monitors and analyses trends in resistance. Now, NRP 72 is focusing more closely on applied research. One reason for this shift in

emphasis is the major advances achieved in recent years in the field of gene sequencing and the biochemical analysis of cellular processes. These advances are enabling new approaches to research and solutions.

### **Different disciplines contribute to solutions**

The spread of antibiotic resistance among humans cannot be dissociated from the presence of resistant bacteria

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and resistance-encoding genes in animals, the food chain and the environment. Consequently, it is essential to take all these areas into account. NRP 72 does this through a comprehensive, cross-disciplinary “one health” approach. The research projects are divided into three modules that investigate various aspects of resistance:

### **Module 1**

#### **Development and spread of resistance**

Many aspects of the development and spread of resistant bacteria are still unknown. To understand the complex processes involved, we need a research approach that combines human medicine, veterinary medicine, biology and environmental sciences. The results of such research will help us to disrupt the processes through which resistant bacteria are able to spread.

### **Module 2**

#### **New drugs and faster diagnostic techniques**

To fight resistant bacteria, both human and veterinary medicine urgently need new antibiotic drugs. Academic research can make a major contribution to their development. Furthermore, faster diagnostic tests are important to identify resistant strains quickly and treat people and animals adequately.

### **Module 3**

#### **Optimised use of antibiotics**

When antibiotics are used excessively or wrongly, resistance is more likely to develop. New decision-making tools and operational processes will help medical and veterinary doctors as well as farmers to use antibiotics more selectively.

# Development and spread of resistance

## Projects:

How bacteria outsmart antibiotics in their sleep

**Prof. Urs Jenal**

Resistance on lettuce plants

**Dr. David Drissner**

Phages and the spread of resistance in different ecosystems

**Dr. Elena Gomez Sanz**

How rapidly bacteria exchange information

**Prof. Sebastian Bonhoeffer**

Sources of resistant germs in the city of Basel

**Dr. Sarah Tschudin Sutter**

Antibiotic Resistance from waste water treatment facilities in Swiss streams and rivers

**Dr. Helmut Bürgmann**

How germs transfer resistance to each other

**Prof. Melanie Blokesch**

## How bacteria outsmart antibiotics in their sleep

Some bacteria can enter a resting state that makes them insensitive to antibiotics. Our goal is to find out how this state works, which role it plays in antibiotic therapy and whether it facilitates the emergence of antibiotic resistance.

Bacterial pathogens can survive contact with antibiotics by modifying their DNA to develop resistance. But there is an alternative way to survive antibiotic exposure, known as antibiotic tolerance. Tolerant bacteria survive exposure to antimicrobial drugs by switching their cell metabolism into a resting state thereby eliminating their susceptibility. The molecular and cellular basis of this condition is largely unknown. We are investigating these processes in the bacterium *Pseudomonas aeruginosa*, a life-threatening human pathogen that is difficult to treat. In addition to uncovering the actual tolerance mechanisms, we are also investigating if and how they are linked to the development of antibiotic resistance.

**Prof. Urs Jenal**

Universität Basel, Biozentrum



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## Resistance on lettuce plants

**Antibiotic-resistant germs are repeatedly found on lettuce. We identify the sources from which they are transferred to the plants during cultivation.**

Antibiotic-resistant bacteria occur in the environment, in soil, bodies of surface water and organic fertilisers used in agriculture. They are presumed to pass from these sources to humans via plant-based food. However, little is known about how these bacteria are transferred from the environment to commercially grown plants. We are studying this aspect in lettuce cultivation and determining the sources from which resistant bacteria are transferred to the plants. We are investigating soil, irrigation water and fertilisers used during growth up to the point the plants are harvested. We are analysing which bacteria are transferred from which sources and in what quantities, as well as which forms of resistance persist until harvesting. Our study looks at both field and greenhouse cultivation.

**Dr. David Drissner**

Agroscope Wädenswil, Institut für Lebensmittelwissenschaften ILM

## Phages and the spread of resistance in different ecosystems

**Some resistance determinants to antibiotics seem to develop and spread in natural eco-systems, which are later transferred to human related systems. We clarify the role that bacterial viruses, so-called bacteriophages, play in these processes.**

The use of antimicrobials by humans is often named as the sole reason for the emergence and rise of antimicrobial resistance. However, genes that make bacteria resistant to antibiotics can also be found in virgin soils and bodies of water. It can be assumed that the origin of some of the resistances encountered in human medicine lies in these eco-systems. We investigate the resistance load in soils and bodies of water and how resistance is transferred between micro-organisms living in them. Our main focus is on bacterial viruses, so-called bacteriophages. They play an important role in the exchange of genetic material between bacteria, and they could also be responsible for the transfer of resistance genes between different eco-systems.

**Dr. Elena Gomez Sanz**

ETH Zürich, Institute of Food Science and Nutrition

### How rapidly bacteria exchange information

**Bacteria exchange plasmids that contain genetic information involved in the development of resistance. We are researching their role and analysing factors that accelerate plasmid exchange.**

One of the ways in which antibiotic resistance spreads is by bacteria transferring genetic material among themselves. This material includes plasmids. In order to clarify the role played by plasmids, we first use bioinformatic methods to estimate how often different types of bacteria exchange plasmids. We also measure this transfer frequency in an animal model using mouse gut bacteria under the influence of different factors such as inflammation or low concentrations of antibiotic. We then record the transfer frequency of plasmids in bacterial cultures in the laboratory. We use all the recorded data to develop mathematical models that calculate the effect of different factors on the transfer rate of plasmids and thus on the transfer of resistance.

**Prof. Sebastian Bonhoeffer**  
ETH Zürich, Departement Umweltsystemwissenschaften

### Sources of resistant germs in the city of Basel

**We are using samples obtained from the Basel urban region to investigate the role played by different sources such as hospitals, foodstuffs and waste water in the spread of antibiotic-resistant bacteria.**

The most common bacterial pathogens in humans include several species of the family of Enterobacteriaceae. Many of them have now become resistant to antibiotics. They occur in hospitals and also on food and in waste water. We are studying the contribution made by each of these sources to the spread of resistant Enterobacteriaceae. To do this we are analysing several hundred bacterial strains found in patients at University Hospital Basel, on food obtained from retail outlets and in waste water from the city of Basel. We are using molecular genetic methods to determine which bacteria are genetically related. By doing so we can identify the ways in which individual bacterial strains spread and highlight the role played by the different sources.

**Dr. Sarah Tschudin Sutter**  
Universitätsspital Basel, Klinik für Infektiologie und Spitalhygiene

Many resistant bacterial strains are found in hospitals. Sarah Tschudin Sutter (right) wants to know whether they are related to organisms from sources outside hospital.





Helmut Bürgmann uses Niskin bottles to take water samples at different depths.

### **Antibiotic Resistance from waste water treatment facilities in Swiss streams and rivers**

**Antibiotic-resistant bacteria pass into watercourses when waste water is discharged. We are investigating how this resistance behaves and where humans come into contact with it.**

Normal waste water treatment facilities do not remove all resistant bacteria from waste water. We are looking at which bacteria, bearing which types of resistance, pass into Swiss streams and rivers in this way and where they can subsequently be found. We are paying special attention to bacteria in aquatic animals, sediments and so-called biofilms: layers of bacteria on the surface of water and soil. We are also recording the distances over which resistance is transported and how robust it is. This information will enable us to develop models to predict the resistance burden of flowing waterways along their courses. The intention is to identify places in which humans could come into contact with resistance from waste water treatment facilities.

**Dr. Helmut Bürgmann**  
Eawag, Kastanienbaum

### **How germs transfer resistance to each other**

**Dead bacteria release DNA molecules that other bacteria can incorporate into their own genetic material.**

**We are investigating the way in which, during this process, they pass on genetic information that leads to the development of antibiotic resistance.**

Antibiotic resistance is spread not only by multiplying resistant bacteria, but also by bacteria exchanging genetic material between themselves. An important role in this process is played by the ability of bacteria to incorporate free DNA present in a medium in which they are immersed. We are investigating this mechanism in bacteria from the species *Acinetobacter baumannii* with the aim of finding out how the mechanism contributes to the development of resistance. Resistant strains of these bacteria are found repeatedly, particularly in hospitals. At this stage it is often no longer possible to treat them due to multi-resistance. In a second step we are analysing how the studied mechanism contributes to the spread of resistance when bacteria come into contact with antibiotics.

**Prof. Melanie Blokesch**  
EPF Lausanne, Global Health Institute

## New drugs and faster diagnostic techniques

### Projects:

Improving established antibiotics

**Prof. Erik Christian Böttger**

Identifying resistance with glass fibres

**Prof. Giovanni Dietler**

Antibacterial weapons from the phyllosphere

**Prof. Jörn Piel**

Smaller means faster: diagnostics on a microchip

**Prof. Petra Dittrich**

Exploiting the natural enemies of bacteria

**Prof. Martin Loessner**

Getting inside the protective shield of bacteria

**Prof. Sebastian Hiller**

Artificial alternative to an important natural substance

**Prof. Jean-Louis Reymond**

## Improving established antibiotics

The aim of this project is to develop new, highly potent antibiotics based on the aminoglycoside compound class.

The aminoglycosides are a class of highly potent antibiotics that are active against numerous bacterial pathogens such as enterobacteria, staphylococci and tuberculosis bacteria. Aminoglycosides are used predominantly in the hospital setting to treat serious infectious diseases. In the past decades, increasing resistance to these antibiotics has developed, and their use is additionally limited by considerable side effects. Taking recent findings on the complex mechanisms of action and resistance of aminoglycosides into account, our aim is to further develop this substance class.

**Prof. Erik Christian Böttger**

Universität Zürich, Institut für Medizinische Mikrobiologie

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## Identifying resistance with glass fibres

**We are developing a new test instrument that identifies bacterial resistance by means of glass fibres and a laser beam. Our aim is to shorten the time between a patient being admitted and the start of appropriate therapy from the current 24 to 10 hours.**

Our method is based on the use of hair-thin glass fibres to which the live bacteria being tested are fixed. Their movements are transmitted to the fibres, the vibrations of which are recorded by a laser and visualised on a computer screen. If a bacterium is susceptible to an added antibiotic, it dies and the glass fibre stops moving after about 10 to 20 minutes. If, on the other hand, the laser is still detecting movement after this time has elapsed, then the bacterium is resistant to the antibiotic that has been administered. The advantages of our method compared with conventional tests are the rapid availability of the result and the possibility of testing different antibiotics in parallel by using several glass fibres.

**Prof. Giovanni Dietler**

EPF Lausanne, Laboratory of Physics of Living Matter

## Antibacterial weapons from the phyllosphere

**A diverse microcosm, called the phyllosphere, exists on the surfaces of leaves. It is here that bacteria wage war on each other with antibiotics. We are systematically analysing these organisms and substances to discover new active substances.**

Today's antibiotics come mainly from naturally occurring bacterial substances isolated from soil samples. However, there exist numerous additional microorganisms with major potential as drug sources that has as yet barely been tapped into. These include bacteria found on leaf surfaces. Our decision to study them was motivated by well-documented evidence that they produce antibiotics as a defence against hostile bacteria. Using state-of-the-art methods of genetic analysis and bioinformatics, we plan to identify bacteria that show considerable promise for the discovery of antibiotic substances. We will isolate and test these substances chemically and pharmacologically with the goal of making especially promising substances available for the development of medicines.

**Prof. Jörn Piel**

ETH Zürich, Institut für Mikrobiologie

Using a fluorescence microscope, Petra Dittrich determines exactly what is happening on the microchip.





### Smaller means faster: diagnostics on a microchip

**We want to use a novel test to make the diagnosis of antibiotic resistance much faster. We are developing a miniaturised process that will directly analyse individual germs on a microchip.**

It currently takes hours or even days to determine whether a germ is resistant to an antibiotic. That's often too long when doctors need to take decisions about treatments. We are developing a new diagnostic method that will deliver reliable results within a few hours. We want to determine not only the type of resistance displayed by a pathogen but also what concentration of what antibiotic is needed to stop the infection. At the heart of our device is a microchip on which minute quantities of germs can be fixed and analysed. The use of such small sample quantities substantially reduces the time needed for analysis compared with conventional methods. We are testing the reliability of our device in the routine clinical setting.

**Prof. Petra Dittrich**  
ETH Zürich, Bioanalytics Group

### Exploiting the natural enemies of bacteria

**Bacteriophages kill bacteria. We are investigating how the bacteriophages' weapons can be used as new therapeutics to combat local infections within the body.**

Bacteria have natural enemies named bacteriophages. They use the bacteria as a host for the purpose of multiplication. When they leave the bacteria, they degrade the bacterial cell wall using specific enzymes, known as endolysins, causing the bacteria to die. We aim to develop therapeutics containing endolysins that are capable of destroying pathogenic bacteria. For them to be effective against local infections within the body, e.g. cases of inflammation of the bones or heart, they need to reach the infected sites. To achieve this, we put special target markers on endolysins. These "biological zip codes" guide them directly to the affected regions in the body.

**Prof. Martin Loessner**  
ETH Zürich, Labor für Lebensmittelbiotechnologie

### Getting inside the protective shield of bacteria

Many particularly dangerous bacteria are protected by an outer membrane. We want to understand the mechanism by which this membrane develops in order to find targets for new active substances.

Infections by so-called Gram-negative antibiotic-resistant bacteria are difficult to treat because these bacteria are protected by two membranes. Yet there are points in the outer membrane that are open to attack by active substances. We are characterizing one of these points, the protein BamA. BamA controls the process of incorporating other proteins into the membrane. If BamA is knocked out, this is fatal for the bacterium. We are studying the function of BamA and the incorporation of proteins at the atomic level, using NMR spectroscopy and X-ray crystallography. This makes the interactions between BamA and other molecules visible. In this way we can gain a better understanding of the mechanisms and look for active substances that interrupt them.

**Prof. Sebastian Hiller**  
Universität Basel, Biozentrum

### Artificial alternative to an important natural substance

We are looking for an alternative to the important natural antibiotic colistin. With this in mind we are systematically exploring related structures by chemically synthesising those that do not occur naturally.

When nothing else works, maybe colistin will. Nowadays this antimicrobial peptide of natural origin is used as the last resort against many multiresistant germs. Yet it can have considerable side effects, and there are now bacteria that are resistant to it. Other peptides offer particular promise in the search for alternatives to this important substance. We have already discovered some that are active against multiresistant bacteria by systematically investigating peptides related to colistin that do not occur naturally. They have never been studied before because they are not natural substances. We are now optimising these artificial peptides, investigating their mechanism of action and assessing which might be useful for medical purposes.

**Prof. Jean-Louis Reymond**  
Universität Bern, Departement für Chemie und Biochemie



First, Jean-Louis Reymond obtains the peptides in solution. In the next step, they are freeze dried to get them in powder form.

## Optimised use of antibiotics

### Projects:

Feedback culture and the rational use of antibiotics in the hospital setting

**Dr. Laurence Senn**

Learning from claim data

**Prof. Heiner C. Bucher**

An algorithm to improve the diagnosis of pneumonia

**Dr. Noémie Boillat Blanco**

Using computers to improve prescription practices

**Dr. Benedikt Huttner**

Online help for veterinarians

**Prof. Hanspeter Naegeli**

Providing the right incentives

**Dr. Stefan Mann**

The “outdoor” calf – a new concept for calf fattening

**Prof. Mireille Meylan**

### Feedback culture and the rational use of antibiotics in the hospital setting

**We are carrying out a study in nine hospitals to determine whether doctors use antibiotics more specifically if infectious diseases specialists evaluate their prescribing habits regularly and provide them with feedback.**

Inappropriate prescribing of antibiotics can promote the development of resistance. We want to make prescribing doctors more aware of the need to use these medicines responsibly. To this end, we are developing a programme in which training is provided by infectious diseases specialists. They also review the doctors’ prescribing habits on a weekly basis and discuss their findings with them. We are performing this intervention in a number of departments at nine hospitals in the French-speaking part of Switzerland.

We have divided the departments randomly into two groups: the intervention takes place in one group, but not in the other. This allows us to check the efficacy of our programme.

**Dr. Laurence Senn**

Centre Hospitalier Universitaire Vaudois CHUV, Unité d’hygiène hospitalière

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## Learning from claim data

We are using claim data from health insurance providers to regularly inform general practitioners about their use of antibiotics. We are testing whether, in conjunction with information about local resistance development, this can improve prescribing habits.

General practitioners (GPs) often prescribe antibiotics indiscriminately for respiratory and urinary tract infections. We want to encourage them to use antibiotics more cautiously. To do this we are using the claim data from the three biggest health insurances (3.8 million insureds, or 40% of the Swiss population) to produce an ongoing evaluation of GPs' prescribing habits. We provide nearly 2,500 GPs with regular feedback on this as well as with information on the development of resistance in their catchment area. We also provide them with guidelines for treating respiratory and urinary tract infections. We then use the data from the health insurances to analyse the impact of this intervention. All the data are anonymous; we do not know the names of any of the doctors or patients.

**Prof. Heiner C. Bucher**

Universitätsspital Basel, Institut für klinische Epidemiologie

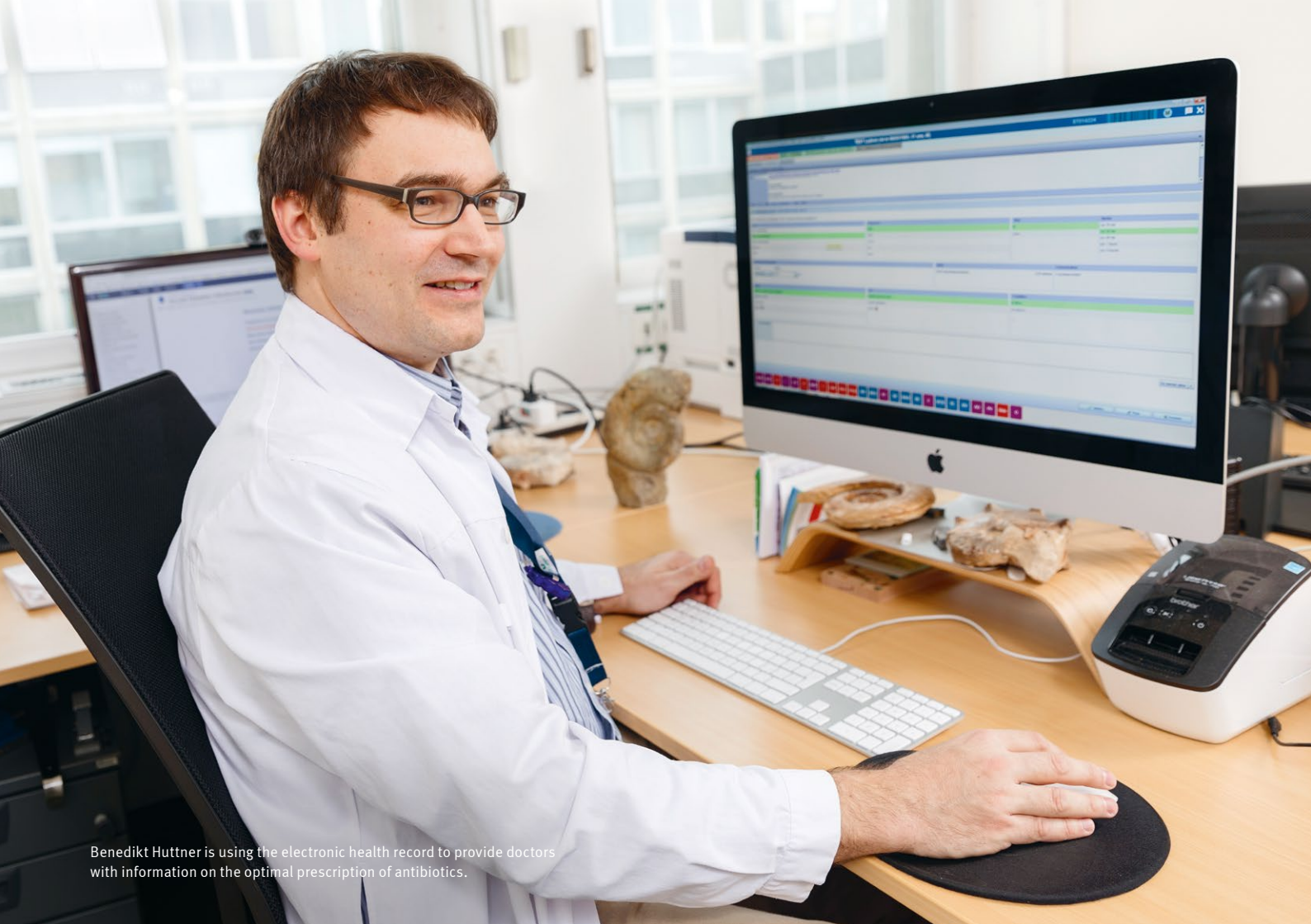
## An algorithm to improve the diagnosis of pneumonia

Current tests do not allow GPs to determine with sufficient accuracy whether a patient has pneumonia requiring antibiotic therapy. We are increasing the precision of diagnosis by combining two new diagnostic tests with an algorithm.

General practitioners too often prescribe antibiotics for acute respiratory tract infections because they cannot distinguish between bacterial pneumonia and non-bacterial infections. In order to improve diagnosis we are developing a procedure that combines ultrasound examination of the lungs with a procalcitonin test helping in differentiating between bacterial and viral infections. However, since each method on its own produces too many unreliable diagnoses, we are combining their results with an algorithm to increase diagnostic precision. In our study, several general practitioners are using this strategy, and we are comparing the amount of antibiotics they prescribe and the therapeutic outcomes with those of a comparator group who are not using the strategy.

**Dr. Noémie Boillat Blanco**

Université de Lausanne, Bagamoyo Research and Training Center



Benedikt Huttner is using the electronic health record to provide doctors with information on the optimal prescription of antibiotics.

### Using computers to improve prescription practices

**We are integrating a tool directly into the electronic health record to give hospital doctors feedback on the way they prescribe antibiotics. This system is being trialled in various hospitals.**

Prescribing antibiotics frequently poses problems in practice, since patients don't always receive the right dosage of the right antibiotic for the right period of time. This promotes the emergence and spread of antibiotic resistance. We are developing a system designed to help doctors to use antibiotics more appropriately. Under COMPASS (COMPuterized Antibiotic Stewardship Study), doctors in three Swiss hospitals will receive tips on the use of antibiotics that are integrated directly into electronic health record. They will also be given regular feedback on their use of antibiotics. Parallel to this, we will collect data on the antimicrobial prescription practices of a control group which is not using the system so that we can monitor the latter's effectiveness.

**Dr. Benedikt Huttner**

Hôpitaux Universitaires de Genève HUG, Département de Médecine Interne

### Online help for veterinarians

**We are launching an online platform for veterinarians that combines practical recommendations on antibiotics and a resistance reporting system. We will conduct three trials to determine whether this optimises and reduces the use of antibiotics.**

Antibiotics are not always used optimally in the veterinary sector, whether for livestock or pets. This prompted us to develop an online platform as a support tool to help veterinarians use them more selectively. In addition to providing simple-to-adopt recommendations, the platform also offers an opportunity to give feedback if a treatment proves ineffective. This not only facilitates efforts to monitor the resistance situation, it also helps to improve recommendations. In order to verify the effectiveness of this tool, we will conduct two trials over a period of three years to collect data on changes in the use of antibiotics at university veterinary hospitals and private practices. We will also carry out a broad survey of Switzerland's veterinary community.

**Prof. Hanspeter Naegeli**

Vetsuisse Universität Zürich, Institut für Veterinärpharmakologie und -toxikologie

### Providing the right incentives

**Positive incentives are crucial for reducing antibiotic use in the agricultural sector. We wish to establish how effective and broadly accepted incentive systems could be constructed.**

The Swiss government's antibiotic resistance strategy (StAR) wants to reduce the use of antibiotics in agriculture. New incentive systems are also to be introduced to bring about a change in behaviour. We are investigating the options for incentive-based tools. Our study relies primarily on surveys conducted among veterinarians and farmers. In an initial phase, we will examine how antibiotics are being used today. Working in conjunction with veterinary practitioners, we will then develop several financial incentive methods designed to reduce the use of antibiotics. Then we will carry out a further survey to ascertain what level of acceptance these options have achieved among the farming community. We will use our findings to prepare recommendations for the relevant federal offices.

**Dr. Stefan Mann**  
Agroscope Reckenholz-Tänikon ART

### The “outdoor” calf – a new concept for calf fattening

**We are testing a new management concept for calf fattening that sets out to halve antibiotic use. In this concept the calves grow up outdoors, with shelters and a covered exercise area.**

In calf fattening operations, young animals from several herds of origin are often gathered to large groups. As a result, they pass on germs to each other that cause a large number of diseases, resulting in the use of large quantities of antimicrobial drugs. We are developing a new management concept for calves called the “outdoor calf”. The animals live outdoors, initially in individual igloos that enable them to be quarantined on arrival at the fattening centre. They are later kept in small groups with igloos and a bedded and sheltered outdoor area. This exposes them to fewer pathogens and they fall ill less often. We will test this concept in 20 herds, comparing the diseases that occur and antimicrobial use with 20 herds using traditional methods in the neighbourhood.

**Prof. Mireille Meylan**  
Vetsuisse Universität Bern, Klinik für Wiederkäuer



Healthy calves need fewer antibiotics.  
Mireille Meylan visits a test facility with an  
interspersed run.



## JPIAMR: Cross-border research

In order to coordinate international research into resistance and collaborate on the corresponding projects, 22 countries are taking part in the Joint Programming Initiative on Antimicrobial Resistance (JPIAMR). NRP 72 finances Swiss research teams participating in JPIAMR projects that are pursuing the same goals.

### Projects:

The secret of ST131's success

**Dr. Laurent Poirel**

How bacteria unify to protect against antibiotics

**Dr. Qun Ren Zulian**

Resistant germs in long-term care and in the home

**Prof. Stephan Harbarth**

How resistance transfers from pets to humans

**Prof. Vincent Perreten**

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## The secret of ST131's success

**There is a type of Escherichia coli bacteria occurring frequently around the world that is resistant to multiple groups of antibiotics. We are investigating how this pathogen acquires and transmits resistance.**

Most urinary tract infections and cases of blood poisoning are caused by E. coli bacteria. Strains resistant to multiple antibiotics are occurring increasingly worldwide, especially one type named ST131. In a project comprising six research groups from five countries, we are investigating why the infectious potential of ST131 is so high, and how it acquires resistance. Our team explores the genetic processes by which E. coli integrates specific genes from other bacteria into its own genome thereby expanding its resistance. In earlier studies we have already identified a genetic element (ISEcp1) that plays an important role in this transfer. We are now analysing the mechanisms that are responsible for the observed processes in vitro.

**Dr. Laurent Poirel**

Université de Fribourg, Medical and Molecular Microbiology Unit

## How bacteria unify to protect against antibiotics

**Bacteria that join together to form colonies (known as biofilms) are difficult to break down with antibiotics. We are investigating the ways in which these biofilms are involved in the development of resistance.**

Most bacterial infections are caused by biofilms. These are bacterial colonies that form a dense coating to occupy a range of surfaces including those of medical products such as implants. In a biofilm, the bacteria surround themselves with protective gelatinous substances comprised of extracellular components. As a result, when treating infections with antibiotics only a small amount of the active agent comes into contact with the bacteria, thus helping to form resistance. In an international research project with partners from four European countries, we are investigating how bacteria in biofilms adapt to antibiotics, how they acquire re-sistance and how this influences the bacterial composition in the biofilm.

**Dr. Qun Ren Zulian**

Empa, Laboratory for Biointerfaces

## Resistant germs in long-term care and in the home

**We are studying the transmission of resistant enterobacteria in long-term care and in the home. Together with the findings from other research groups we aim to provide a comprehensive picture of the ways in which these pathogens spread.**

Multi-resistant intestinal microbes of the enterobacteria family are spreading rapidly all across the globe. Switzerland has also seen an increase of new infections. The pathogens can be found in hospitals, homes, on food and in the environment. Working together with research groups from six European countries, we seek to explain the precise ways in which they spread. Within the framework of our subproject, we are investigating how resistance is transferred within long-term care institutions and private homes. We are analysing various strains of enterobacteria, as well as mobile genetic elements that are exchanged between bacteria and play an important role in the formation of resistance.

**Prof. Stephan Harbarth**  
Université de Genève, Department of Internal Medicine Specialties

## How resistance transfers from pets to humans

**Close contact between pets and their owners creates more favourable conditions for the transfer of antibiotic resistance. An international research project is investigating which infections and situations pose the greatest risks.**

With increasing frequency, humans are contracting infections from antibiotic-resistant pathogens transferred from their pets. A consortium of research groups from four European countries and Canada is seeking to explain the circumstances that make the exchange of pathogens and resistance genes between humans and animals more likely. Our team is assisting in an advisory role, as well as carrying out molecular analysis of resistance genes. The project focuses on the processes during the acute stage of an infection, since the relevant bacteria and resistance genes increase greatly during this time. By studying pet owners and their animals over a longer period, it is possible to determine the transfer risks of a range of infections at different points during the course of the infection.

**Prof. Vincent Perreten**  
Vetsuisse Universität Bern, Institut für Veterinärbakteriologie

## Using and promoting the interface between science and practice

The results of NRP 72 will be implemented in practice. For this reason, we attach great importance to continuous, open dialogue with a range of stakeholders.

NRP 72 will develop new solution approaches in the fight against antimicrobial resistance. So that our results and knowledge will have the greatest possible effect, we place high value on transferring knowledge and technology into practice. These activities are aimed at diverse stakeholders in different sectors, given the broad range of topics covered by the NRP 72 research projects. Included are new strategies in the practice of human medicine, veterinary medicine and agriculture; new approaches to antimicrobial

drugs and diagnostic methods; and new approaches to preventing the spread of resistance between humans, animals and the environment.

### **Building and using interfaces**

The target groups for practical application are very diverse. They include health-care and pharmaceutical companies, as well as agricultural societies and organisations. We would like to establish an ongoing dialogue with all of them. To do that efficiently, we will organise the knowledge and technology transfer

activities according to the major thematic areas of NRP 72. Within these areas, we will build exchanges between scientists and partners from the practical realm by using existing interfaces but also by creating new possibilities for networking as needed.

### **Close interaction with StAR**

NRP 72 works closely with the government administration, namely with the authorities responsible for implementing the National Strategy on Antibiotic Resistance (StAR). NRP 72 will provide

them with effective and practical recommendations for action. However, the cooperation with StAR will also serve to sensitise researchers to the political processes that are crucial to the success of knowledge transfer. Particularly when it comes to changing behaviour, conflicts of interest between different affected stakeholders, for example, must be taken into account.

### **Connecting researchers**

By bringing researchers from different disciplines together, NRP 72 provides new impetus in the fight against antimicrobial resistance. This interdisciplinary approach offers major opportunities but also poses challenges to communication among scientists. To encourage knowledge transfer between them, NRP 72 provides a range of possibilities, including yearly exchange meetings for all scientists and joint workshops in thematic

areas. The resulting network will strengthen research on antimicrobial resistance beyond the duration of the NRP.

### **Constant and transparent information**

Public communication about the content and organisational processes of NRP 72 supports knowledge and technology transfer. We regularly and openly provide information regarding advances as well as any problems that crop up. This creates credibility and trust, which are essential in giving science a voice in public and political debate.

## Management

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# Procedure







### **The Swiss National Science Foundation**

The Swiss National Science Foundation (SNSF) is Switzerland's leading provider of scientific research funding. Commissioned by the federal government, it supports research work in all academic fields, from philosophy and nanoscience to biology and medicine. The focus of its activities is the scientific endorsement of projects submitted by researchers. Yearly, approximately 3000 projects are funded by the SNSF with a total amount of approximately CHF 750 million.

### **Copies of this brochure can be obtained from:**

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### **NRP 72 in brief**

NRP 72 develops both basic and applied scientific solution approaches to overcoming the problem of antimicrobial resistance. The NRP is funded in the amount of 20 million Swiss francs. The programme's research projects will be conducted in higher education institutions throughout Switzerland and completed in 2021.

### **NRP 72 has the following objectives**

- To discover and disseminate new knowledge about resistance that can disrupt these processes.
- To develop new antimicrobial drugs and faster diagnostic tests to improve medical treatment of humans and animals.
- To develop methods that will help clinicians, veterinarians and farmers to use antibiotics more selectively.