Uppsala HEALTH SUMMIT

Pre-conference report

Managing Antimicrobial Resistance Through Behaviour Change

15–18th March 2021
Online from Uppsala

Uppsala Health Summit is an international arena for frank and challenging dialogue, exploring possibilities and implementation challenges associated with advancement in medicine and public health. Uppsala Health Summit stimulates dialogue from various perspectives, such as medical, economic and ethical.

We are an enabler for change, and an arena for insights and collaborations that can help you improve health outcomes in your part of the world.

Uppsala Health Summit is organized by partners with long experience of developing health and healthcare solutions through multi-disciplinary efforts.

The meeting is a collaborative effort between Uppsala University, the Swedish University of Agricultural Sciences, Uppsala County Council, the City of Uppsala, the Swedish Medical Products Agency, The National Veterinary Institute, Uppsala Monitoring Centre, and the network World Class Uppsala.

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Preface

Antimicrobial resistance is an ever-increasing threat to human health. One by one, the medications we rely on in modern medicine are losing their power.

Despite heightened awareness that cancer treatments, childbirth or simple medical procedures are becoming unsafe, antimicrobial resistance has failed to get the attention it deserves, partially due to perverse economic incentives for overproduction and use of antibiotics. Another reason is the complexity of the challenge: Where do we begin, what actions matter, and how can individual behaviours change with respect to an issue that may not immediately affect each of us individually?

Complex issues demand multiple responses that engage different actors. At the Uppsala Health Summit on Antimicrobial Resistance and Behaviour Change, we will draft ideas for policy and actions. Together with researchers, practitioners, industry and policymakers, we aim to encourage new thinking to be put into action.

In Uppsala, we feel well-suited to host a discussion on this important theme. We have two leading academic institutions with scholars conducting internationally renound research in the field: Uppsala University and the Swedish University of Agricultural Sciences. The activities of the two universities – along with our other Uppsala-based, not-for-profit partners supporting the Uppsala Health Summit – have created a hub for multi-disciplinary research, practice and advocacy regarding antimicrobial resistance.

The Uppsala Health Summit was created to bring medical, ethical and economic perspectives together to address challenges and dilemmas, with a view to improving health outcomes all around the world.

Due to Covid-19, the summit will be digital for the first time. This has an advantage: We can engage more participants, provide greater outreach and a stronger voice for change.
I welcome you to take part in this effort and invite you to become engaged in the challenging and rewarding discussions taking place at the Uppsala Health Summit!

Anders Malmberg, Professor
Departing Chair of Uppsala Health Summit
Steering Committee

Can we manage the antimicrobial resistance crisis by changing our behaviours?

Ulf Magnusson, Professor, Swedish University of Agricultural Sciences,
Chair of the Uppsala Health Summit Programme Committee

We are living in the midst of a severe pandemic that is taking its toll in many different ways all around the world. However, under the surface, there is another, less immediate health crisis that is gaining more and more ground: The emergence of antimicrobial resistance (AMR). There are several reports predicting that, over time, the AMR crisis will have an even more devastating impact on health and countries' economies than the current pandemic.

The theme of the current Uppsala Health Summit – *Managing Antimicrobial Resistance Through Behaviour Change* – was set several months before the start of the pandemic. Since then, the relevance of, and need for, health-related behavioural changes has become well understood by the public and policymakers around the world. The Covid-19 pandemic has also been a stark reminder that infectious diseases do not respect country borders and has highlighted the importance of global collaborations. In addition, when trying to prevent and control pandemics and the emergence of AMR alike, the importance of considering the health of humans, domestic animals and the environment concurrently is a realization that is gradually being taken up by professionals as well as policymakers around the world. Consequently, we have fully embraced the "*One World, One Health*" approach in the programme committee of the Uppsala Health Summit when addressing behaviour change as a means of managing the emergence of AMR.

Improved national policies and international declarations and agreements are good support instruments for curbing the emergence of AMR. However, how well such regulatory means, which often imply restriction of antimicrobial use, are translated into change is very context specific. Different jurisdictions have different capacities to enforce regulations, depending on their resources, political priorities or traditions related to compliance with regulations in general. Another, complimentary approach is to introduce non-regulatory incentives along the whole chain, starting from production of the antimicrobial until it ends up in a human, animal or the environment. At this 7th Uppsala Health Summit, we will explore the opportunities and limitations of behaviour change approaches targeting individuals and organizations as a means of managing the emergence of AMR.

Besides the high-quality plenary sessions, there will be eight interactive workshops where we will discuss how different aspects of behaviour change can play a role in reducing the threats of AMR.

Cross-sectorial exchange for better prevention

On the whole, we know what to do to prevent the spread of resistant bacteria. But it is clear that we are simply not doing these things often enough. How can we get people to practise the desired preventive behaviours? One approach is

In the One health approach for curbing the AMR emergence, it is important to consider the use of antibiotics in domestic animals.

to bring together sectors with seemingly different drivers and solutions. This may lead to new insights that help us move forward. Putting experiences from the health care sector, where health workers have the ultimate responsibility for patients, together with the livestock sector, where it is the farmer who has the ultimate responsibility to protect his animals from disease, may allow us to identify successful commonalities concerning how to change behaviour. But how should we ultimately work to move AMR-preventive behaviours in the right direction?

Improving Communications

Even if the severity of the emerging AMR is well known and understood among several groups of stakeholders, there is reason to be disappointed by the seemingly poor response from society as a whole. Is this due to a communication failure on the part of the informed scientific community? Obviously, there are some specific challenges associated with communicating about AMR: It is a slow-moving crisis and thus not regarded as an urgent problem. Furthermore, it is a complex issue to communicate and misunderstandings abound. For instance, messages must communicate that it is the 'bugs' that become resistance, not you, and that it is not the antimicrobials *per se* that are dangerous, but the fact that they make bacteria resistant. Furthermore, using an overly alarmistic tone in communication may have unintended consequences and turn people away from facing the problem.

Preventing risk of infection in animal-human interactions

It is generally accepted that child-animal encounters are beneficial for children's' learning and social development. These encounters may be in the form of children having pets in the family or living on or visiting farms with cows, pigs, and horses. However, close contact with animals also poses a risk to children from an AMR perspective: Resistant bacteria may be transmitted from the animal to the child. So, how great is this risk compared with the benefits for children of tending to and interacting with animals? And how do we harness these benefits in view of the risk of transmission of resistant bacteria?

Children as change agents

The emergence of antimicrobial resistance puts the children of today at risk of facing an adulthood with very few pharmaceuticals that are effective against infections. But children may

The tremendous progress made in the health sector are under threat from the emergence of AMR.

function as change agents regarding use of antimicrobials if they have access to an adequate education that allows them to feel competent, able and willing to contribute to a positive development. To achieve this, it is not sufficient to teach the basic life science facts about AMR. It is also a matter of learning about social norms and political and economic priorities related to antimicrobial use. However, exactly what such instruction should specifically address is largely unknown. Moreover, how can we instil in teachers the confidence they need to teach such a complex issue – one ranging from microbiology to political sciences – and to do so while also taking up the conflicting interests?

How can we influence consumer attitudes and behaviour?

Antimicrobial resistance generated by using antimicrobials in food production – mainly in the livestock sector, but also when growing vegetables – may occasionally be transferred to humans and become a health issue. The question is: Is it possible to mitigate this risk by changing consumers' behaviour so they choose food that is produced using less antimicrobials, thereby forcing producers to use less antimicrobials? In such efforts there are several options. For instance, perhaps nudging with a view to slowly changing social norms would be effective. Or are financial disincentives a better way to change consumers' behaviour?

An environmental perspective – What are the opportunities for behaviour change?

Antimicrobials often end up in the environment, and how they get there, thrive and move on or generate resistance in environmental microbes is obviously a very broad issue. For this reason, it is necessary to identify key points where behaviour change could make a difference. Adding to this complexity, the contexts are, very different in countries at varying income levels. When these key points for behaviour change are identified, a new set of questions arises. Who are the targets of behaviour change promotion? And in what forums should such efforts take place? Also, does the order of our attempts to change behaviour matter for the outcome?

Addressing supply shortages

In parallel with the increase in AMR that causes antibiotics to lose their efficacy, there is also a shortage in the supply of these drugs. This may accelerate antibiotic resistance, as suboptimal antibiotics have to be used instead of the most efficient types. This is most likely to happen in low-income countries. Why do these shortages occur and what can we do about them? Various solutions to this problem have been discussed, one being more transparent supply chains with better profitability for suppliers.

New solutions to the R&D challenge?

There has been a dearth of new antibiotics since the 1980s, with only a few new ones reaching the market during the past 30 years, despite the fact that they are greatly needed. This has been due to the scientific challenges associated with developing new classes of antibiotics and because pharmaceutical companies don't find it profitable to invest in such development. Academics and policymakers have identified incentives to stimulate developers of new antimicrobials, but why haven't these been fully implemented and why aren't they functioning as expected?

The summit

We look forward to gathering stakeholders from different policy areas, academic disciplines and geographies for a dialogue on the role of behaviour change in efforts to address the complex field of AMR.

Organizing a meeting virtually is of course a challenge, given that the hallmark of the summit has been collegial networking in the fabulous old Uppsala Castle. However, thanks to our team's efforts, we are reassured that this time, too, the workshops will be characterized by a dynamic and productive atmosphere. And as mentioned, the plenary sessions held by world-leading experts will now be available to a much wider audience!

Suggested readings

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Workshop A

Why not practise knowledge?

The art of disease prevention

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Introduction

Preventing infections and the spread of antibiotic resistant bacteria is a key component of the containment of antibiotic resistance. Fewer infections in a population or sub-population mean a reduced need for antibiotics. This is true in health care, but also in livestock production.

We know enough about what needs to be done to prevent infections and the spread of resistant bacteria, but these measures do not occur often enough. Bringing sectors with seemingly different drivers and solutions together may lead to insights that can help to move things forward.

The health care sector was chosen because it is ultimately responsible for delivering safe care for patients. The livestock sector was chosen because it is the farmer who is ultimately responsible for implementing biosecurity to protect his/her animals. The veterinarian can give advice, but it is up to the farmer to make the decision, including tackling the potential economic consequences of improvements. Several parallels exist between the two sectors concerning the importance of a safety culture, appropriate behaviour and personal motivation.

Many measures taken to implement infection prevention and control (IPC) are straightforward. It has long been known that basic interventions like hand hygiene, appropriate clothing, etc., protect patients from becoming infected and from becoming carriers of resistant bacteria. Fewer infections in hospitals mean lower antibiotic use and lower costs. There is a great deal of knowledge not only about what should be done, but also about how to implement known measures. But having the science and guidance established does not necessarily mean that people will live up to the recommendations.

At the farm level, the basic principle is also clear: "Keep infections out, and should you get them in, try to limit the spread within the premises". But biosecurity at farms can leave much to be desired, even in high-income countries. The challenges are even greater in low- and middle-income countries where access to adequate advice may be limited. Farmers may then rely on professionals with less interest in reducing the need for pharmaceuticals. In addition, the resources needed to invest in improvements may be limited, in particular for small-scale farming.

The focus areas of the workshop are:

- What determines when measures to prevent infections are, or are not, translated into practice?
- How can we work to change behaviours in the right direction?

Wearing protective clothing and changing shoes before entering a stable can prevent introduction of infections. With a simple wooden barrier, visitors to the animals are reminded of these important measures.

Background

It is possible to prevent infections from spreading between patients and health care workers, and there is evidence for how to do this. Still, in 2010, the WHO estimated that as many as one patient in ten acquired an infection during care. This additional and often avoidable burden is costly, both in terms of health and economy, but it also contributes to increased use of antibiotics. Thus, with improved IPC, antibiotic use in hospitals is expected to decrease and the spread of multiresistant bacteria to be slowed. An IPC programme should include not only guidance and training, but also mechanisms for assessment and reassessment. The aim should be one of continuous improvement, and actions should be tailored to each specific setting. Some problems that need to be tackled may be structural, but much of what needs to be done is at the point of care. This includes simple things, such as always disinfecting one's hands before and after contact with a patient. If use of such practices is suboptimal, people will need to rethink and change the way they do things.

It is equally possible to prevent many infections from spreading among livestock. Preventing infections at the farm level leads to healthier animals, which in turn leads to a reduced need to use antibiotics. Presumably, production would also be better. As for health care, the key elements of change are known. Some changes may be structural, such as improving farm construction. But there are also simpler things, like paying attention to the health status of farms that supply animals, quarantining recently arrived animals, changing shoes when entering each stable and wearing protective clothing specific

The WHO has estimated that as many as one patient in ten acquire an infection during care. Many of these infections are avoidable.

to each stable. Washing and disinfecting the stable before putting new animals in it is another example. Employment of these practices may be suboptimal, perhaps partly because the cost of common production diseases has been poorly studied. In a short-term perspective, routine use of comparatively cheap antibiotics may seem to be the best way to tackle disease problems. Again, this requires that the farmer rethink and change attitudes and behaviours, moving towards more sustainable use of antibiotics.

From knowledge to action

Research has shown that taking the step from knowledge to action is complicated, and the effect of new knowledge on changing habits is low. Furthermore, in many situations, more than one factor must be considered, as human or animal health factors as well as economic and cultural ones are highly relevant when deciding how to act. When all of these three factors need to be taken into account, there are no easy answers to be found, as these factors often are experienced as being in conflict with each other. In other words, a decision requires some form of prioritization or trade-offs to be made. It is perhaps for this reason we can observe the difficulty of changing habits and practices – it requires us to make new prioritizations.

The need to change is often experienced when old habits are disturbed. In such situations, the need for reflection and innovative thinking becomes visible to others and to ourselves. If people are not experiencing disturbances, a change in habit is not likely to occur. On the other hand, such disturbances may not lead anywhere, because change requires innovative thinking and acting, which do not happen automatically. Thus, if we are to make changes, some form of support is often necessary. The question is what support would be fruitful? Could it be that

PHOTO CREDITS: © JIM HOLDEN / ALAMY STOCK PHOTO

Hand hygiene is crucial to prevent spread of infections in health care, animal production and food-processing.

support that involves collaborative learning processes might be a solution, i.e., when people get together to learn from each other with a view to coming up with innovative solutions?

Suggested readings

FAO website on antimicrobial resistance
http://www.fao.org/antimicrobial-resistance/en/

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WHO. Implementation manual to prevent and control the spread of carbapenem-resistant organisms at the national and health care facility level. World Health Organization; 2019 (WHO/UHC/SDS/2019.6). Licence: CC BY-NC-SA 3.0 IGO. https://apps.who.int/iris/bitstream/handle/10665/312226/WHO-UHC-SDS-2019.6-eng.pdf?ua=1

WHO website on infection prevention and control
https://www.who.int/teams/integrated-health-services/infection-prevention-control

Workshop B

Lots of talk but little action

What's hindering implementation of incentives to stimulate antibiotics R&D?

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Why should we discuss incentives for antibiotics R&D?
Because antimicrobial resistance (AMR) makes existing antibiotics ineffective, new antibiotics need to be developed and brought to market. However, there has been a dearth of truly innovative antibiotics since the 1980s due to both scientific challenges and lack of financial incentives for drug developers. Whereas the incentives necessary to stimulate developers and their potential effects have been identified by academics and policymakers, no major rewards for developers have yet been introduced, and other incentives such as collaborative research and development (R&D) platforms have not been fully implemented. Why is it the case? What obstacles are currently blocking full implementation of these important incentives?

Aim of the workshop
During this workshop, the discussion will focus on the obstacles that are potentially hindering implementation of three important incentives: Market Entry Rewards, Milestone-based Payments, and Pipeline Coordinators.

There has been a dearth of truly innovative antibiotics since the 1980s, due to both scientific challenges and lack of financial incentives for drug developers.

Background

The Covid-19 pandemic and the risk of secondary bacterial infections have cast light on the importance of having efficacious antibiotics available. However, they have also increased the consumption of antibiotics as prophylaxis and without medical prescription. This implies that the pandemic has once again highlighted *the triple challenge of AMR*: the need for stewardship in use, for global access, and for new drugs that can combat resistant bacteria. In this critical era, World Health Organization (WHO) Director-General Dr Tedros Adhanom Ghebreyesus stressed "…the importance both of protecting the antimicrobials we have and developing new ones, to effectively treat infections, preserve health gains made in the last century and ensure a secure future".[1]

Already 20 years before the Covid-19 pandemic, the WHO recognized AMR as a global health challenge and formulated a strategy to address it (WHO, 2001). However, the global response was rather disappointing. In 2015 the WHO endorsed a "Global Action Plan on AMR", which was supported by the UN General Assembly. This plan also explicitly stressed the need to stimulate the development of new antibiotics. But why does development of drugs as obviously important as antibiotics need to be stimulated at all? Isn't their value in treating life-threatening infections or enabling surgery and chemotherapy enough to induce multitudes of drug developers to engage and push these molecules through their R&D pipelines? Unfortunately, here there is a strong disconnect between the societal and public health value of antibiotics, on the one hand, and their economic value – that is, how much profit developers can reap from launching them to market – on the other.

The challenge

The problem is basically that antibiotics as a business is financially unattractive, certainly less attractive than other therapeutic areas such as cardiovascular diseases or cancer, which provide developers with greater economic returns (Spellberg et al., 2015). This lower profitability depends on scientific challenges – having already picked the "low-hanging fruit", developing new antibiotics has now become increasingly more difficult, resulting in longer development times and higher costs – as well as on higher risks of failure than previously experienced (Payne et al.,

1 https://www.who.int/news-room/detail/01-06-2020-record-number-of-countries-contribute-data-revealing-disturbing-rates-of-antimicrobial-resistance

2015). Since 2000, only three new classes of antibiotics have been launched to market, and they had all been discovered in the 1980s or earlier. Moreover, even if a developer were able to eventually develop a new antibiotic, the revenue side is still problematic: Sales are not only uncertain for a new product, especially one targeting a new type of resistant bacteria, but they are most likely going to be very modest thanks to important stewardship interventions to contain inappropriate use of new antibiotics. The financial paradox is that sales of the newest products will have to be kept low if we are to curb antibiotic resistance.

Accordingly, we are facing a market failure (Kesselheim & Outterson, 2011): Despite the immense societal value of antibiotics, the risks and costs involved are much higher than the revenues antibiotics developers can expect. This is why most of the large pharmaceutical companies have left the antibiotics field during the past 20 years. Out of 25 large pharmaceutical labs focusing on antibiotics in the 1980s, only a handful are left (Outterson et al., 2015). A key role in developing antibiotics has recently been assumed by several SMEs (small and medium-sized enterprises), but these developers are often underfinanced and may be unable to complete their R&D projects or even to survive if they do indeed bring products to market (Wellcome Trust, 2020).

Even if the pipeline of antibiotics in clinical development in 2020 amounted to about 50 antibiotics, many of them were not considered sufficiently innovative or relevant to address the most serious infections (Wellcome Trust, 2020). Moreover, considering the high risk of failure before reaching market approval, there is no guarantee that any truly innovative antibiotic will reach the market in the next decade or so. This would further extend the "discovery void", i.e., the time since the discovery and market launch of the last new class of antibiotics (lipopeptides) in 1987 (ReAct, 2020).

Actions taken, but more are needed

In order to address the dearth of innovation in the antibiotics field, academic and policy analyses have singled out several incentives to stimulate antibiotic R&D with the aim to result in new drugs that are effective against resistant bacteria. For instance, the DRIVE-AB Project (2018) and the AMR Review (2015) feature several "push" incentives that finance developers' activities by covering their costs, as well as "pull" incentives that reward developers when they reach certain development goals.

However, while the incentives and their possible effects have been identified, researched, and analysed over the past 5 years or so, most of them are still far from being implemented. Nevertheless, public and private R&D actors, healthcare, and industry have all clearly expressed their need for incentives that will trigger behavioural changes on a systemic level – namely recreating a functioning antibiotics R&D infrastructure and even bringing private investors back into this area. These actors have particularly expressed the need for "pull" incentives as well as for improved coordination and continuity of innovation support in the antibiotics pipeline.

The workshop

The aim of this workshop is to investigate why, as the leader of the UK AMR Review Lord Jim O'Neil puts it, there have mostly been "empty words" coming from global policymakers.[2]

This workshop invites stakeholders from the private, public and non-profit sectors to identify and discuss *what obstacles are currently blocking* full implementation or permanent establishment of the three main incentives identified in academic and policy analyses: Market Entry Rewards, Milestone-based Prizes, and Pipeline Coordinators. The aim of the workshop is not to evaluate the strength and weaknesses of these incentives per se, but to identify the obstacles blocking their implementation. The contents of these incentives are as follows:

Market Entry Rewards: Financial payments to a developer or intellectual property holder *after* the achievement of market authorization of an antibiotic that meets pre-defined product criteria. The prize money is paid out incrementally, for example over the first five years after market launch. This prize, in turn, aims to either fully or partially replace future revenues from sales of the new antibiotic in question in order to relieve pressures to maximize sales, as such pressures increase the risk of triggering premature resistance development. The size of this kind of inno-

2 https://www.bbc.com/news/health-47719269

vation prize must be large enough to incentivize developers to take on the very considerable costs and risks associated with taking a new antibiotic all the way to market.

Milestone-based Prizes: Monetary outlays offered to developers *after* the achievement of clearly specified R&D goals, including addressing particular diseases. Milestone prizes are "pull" incentives, like Market Entry Rewards, but are considerably smaller (Baraldi et al., 2016; Mossialos et al., 2010). Rather than rewarding a developer for taking a drug all the way to market, the Milestone Prize is intended to take the development of an important antibiotic successfully through a certain development phase. The prize is paid out immediately following the phase in question and would involve sums considerably greater than the cost of development for that phase. The milestone prize is, thus, an innovation prize that incentivizes short-term development goals. For this reason, it may be more suitable for small, or otherwise cash-strapped, developers.

Pipeline Coordinators: A governmental/non-profit organization that closely tracks the antibacterial pipeline and actively supports R&D across all priority pathogens *during* the development process, employing new financing tools. Specifically, a Pipeline Coordinator is an organization that brings together public and private stakeholders and that, using highly flexible tools and working methods, closely monitors the development of antibiotics, identifies gaps in the pipeline, and actively supports (or directly conducts) R&D projects with a view to filling these gaps. As Pipeline Coordinators may use several tools and are active along the whole development pipeline, the effectiveness and efficiency of such incentives are both more promising and more complicated.

While these three incentives can provide advantages by strengthening the global antibiotic R&D pipeline and eventually support bringing new antibiotics to market, they have neither been fully implemented nor made permanent. This suggests that the incentives have been met with resistance, hesitation, or lack of interest on the part of stakeholders. Possible obstacles include funding the incentives, their complexity and difficulty of application, as well as the various actors' perceptions concerning potential unexpected, potentially skewed, or crowding-out effects (Baraldi et al., 2016).

During this workshop, we will begin by identifying which specific obstacles to implementation actually apply to each of the three incentives and, then, we will discuss how these obstacles can be tackled so as to enable implementation of the incentives.

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Suggested readings

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Workshop C

Consumer behaviour and antibiotic resistance

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The food we consume contributes greatly to antibiotic resistance. Consumers can be a driving force in the market because, through their choices, they can influence what food is produced and how. While many may agree in principle with more sustainable consumer behaviour, barriers of different kinds hinder engagement in such behaviour. Several measures can be considered for bringing about the desired changes, including the use of social pressure.

Aim of the workshop

The aim of the workshop is to discuss the role of consumers and strategies for influencing consumer behaviour so it plays a lesser role in promoting antibiotic resistance.

- Should we nudge consumers towards more sustainable purchasing behaviour?
- How can we use the benefits of social norms to overcome the mental barriers of consumer purchasing behaviour?
- Could a system of financial incentives and disincentives be implemented to nudge consumers towards more sustainable antibiotic purchasing behaviour?

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Consumers can play an important role through their choices on how foods are produced.

Background

The use of antibiotics in veterinary medicine, aquaculture and agriculture contributes to the clinical problem of resistant disease in human medicine. Globally, a large portion of antibiotics are employed for growth promotion and disease prevention, thus not to treat sick animals.

Antibiotic resistance can be spread through the environment and the food chain via direct or indirect exposure. Direct exposure occurs during human-animal contact, for instance in the process of rearing pigs. Indirect contact occurs as a consequence of consuming contaminated food. This includes fruits and vegetables, which can also be contaminated by bacteria on the farm or later through cross-contamination.

The World Health Organization (WHO) recommends an overall reduction in use of antibiotics in food production to preserve the effectiveness of these medications in human medicine. But who is responsible for making the appropriate changes? The WHO's primary audience is policymakers and regulatory officials overseeing food production. Nonetheless, the WHO underlines the important role that consumers can play. Through their choices, consumers can act as a driving force in the market and have a strong influence on the way foods are produced (WHO, 2017).

Consumers' behaviour

The majority of consumers indicate that sustainability is of high subjective importance. For instance, people state that it is essential to reduce the use of antibiotics. At the same time, many consumers also engage in unsustainable antibiotic consumption behaviour. The question is: Why do even consumers who are oriented towards "antibiotic responsibility" display unsustainable consumption behaviour? Under the umbrella of the so-called attitude-behaviour gap, this question has been and still is a controversial topic discussed in the area of consumer behaviour research (Eckhardt, Belk & Devinney, 2010). If consumers are to make more informed decisions about how they purchase and consume food, they need access to both relevant information and decision support. However, it is more difficult than one might think to get consumers to act in an antibiotic-free manner. Previous studies

Choose the right product from a large variety of options. Easy or not?

have shown that consumers' decision-making is driven by hedonism and emotions and that the cultural context base consumers experience is of great importance to their behaviour (Parker & Tavassoli, 2000). Furthermore, consumers' behaviour patterns show almost no planned and structured consumption, which could push consumers to buy products without regard to antibiotic content. Studies have shown that consumers' involvement in food issues is based on their desire to save money rather than to act more sustainably (Stancu, Haugaard & Lähteenmäki, 2016). In many respects, consumers can therefore be said to be reluctant to move towards more antibiotic-free consumption. Nonetheless, studies (Proschaska, Redding & Evers, 2008) show that forced behaviour change does not tend to lead to long-term change. To achieve enduring change, it is necessary to anchor, in different ways and using different methods, any behavioural change in consumers' needs and conceptual world.

However, we speculate that there are also intrapsychic consumer conflicts involved in the form of behaviour rationalization. Consumers seem to be motivated to rationalize because they want to reduce or avoid feelings of guilt (Murphy & Dacin, 2011) – first, because individuals are eager to maintain their "sense of goodness" and avoid self-condemnation, as stipulated by self-affirmation theory (Mazar, Amir et al., 2008), and second, because individuals are driven to achieve harmony between their internalized moral values and behaviour, as predicted by cognitive dissonance theory (Festinger, 1957). Recent research shows that laypeople can conceive of the erosion of antibiotic effectiveness due to human activities as an ethical issue and, furthermore, that they can feel they have the responsibility to act in a fashion that promotes the common good, even if some individual effort is involved (Dao, Douglas et al., 2019).

Bandura (2002) has developed different categories of rationalizations that individuals use to morally disengage from shameful behaviour. *Moral justification* is used to depict the behaviour as morally and socially admirable. Individuals using this category often claim that their misconduct served a higher purpose. *Advantageous comparison* is often used to make misconduct look more benign. By comparing one's own act of misreporting to a more egregious example of misreporting, one's own act is reconstructed as almost trifling and of little importance by comparison. *Displacing responsibility* is another common rationalization that is used to reduce agency in relation to the misconduct. By claiming that misreporting occurred under social pressure, individuals can deny responsibility for the act or project it onto someone else. Rationalization implies that individuals search for reasons and evidence to justify misreporting to the self (Haidt, 2001).

Barriers and the need to overcome them

Mental barriers constitute another factor affecting consumer behaviour. These barriers are either driven by emotions or based on effort level. The emotionally driven barriers are based on different behavioural factors, such as negative or positive attitudes and values, while the barriers based on effort level rely on how willing the consumer is to make the necessary effort to change his/her behaviour.

Major efforts to try to change consumer behaviour have been made, but it seems that consumers need to be approached from several different directions. Punishments, rewards and regulations are the different methods that have been used to put pressure on consumers. Recent studies have looked at the possibility of socially encouraging consumers to display correct behaviours, which means putting social pressure on them to act sustainably in their use of antibiotics. Behavioural studies have highlighted the role of social norms in bringing about desirable behaviour changes (Nyborg et al., 2016). Effective approaches to stewardship could include appropriately targeted awareness campaigns about food consumption and responsible consumption, which could have positive effects by educating citizens to be socially conscious.

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Workshop D

Antibiotics and antibiotic resistant bacteria in the environment

How can behaviour change become part of the solution?

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Introduction to the workshop

The attention being paid to the issue of pharmaceuticals, especially antibiotics, in the environment is increasing, the focus being on pharmaceuticals in water. Antibiotic residues or antibiotic resistant bacteria may end up in the environment after production, after consumption, after disposal and even after wastewater treatment. Human behaviour is involved in all of these processes. It is known that antibiotics, even in low concentrations, can alter the micro-flora and stimulate the development and spread of antibiotic resistance in bacteria. One of the main concerns with antibiotics in the environment is that antibiotic resistance will be transferred to commensal (normal flora) bacteria and/or to clinical pathogens, e.g., through horizontal gene transfer. This could lead to bacterial infections that are difficult to treat or even untreatable, which in turn would lead to increased morbidity, costs and mortality. However, thus far, the problem of antibiotic residues and antibiotic resistance in the environment has mainly been described, and mitigation strategies or solutions – e.g., take-back programmes and efficient waste-water treatment plants – are largely lacking globally. Besides the risk of resistance leading to infections that are more difficult to treat, there are also numerous other risks associated with having antibiotic residues and antibiotic resistant bacteria and genes in the environment. Those risks can be both to the environment itself and to animal and human health. Increased efforts are thus needed to find solutions that focus on different aspects, not least behavioural aspects, with a view to reducing antibiotic residues and antibiotic resistant bacteria and genes in the environment globally. The workshop will focus on finding and prioritizing effective and feasible behavioural interventions.

Main focus of the workshop

The issue of antibiotics in the environment is very broad and cuts across all societal sectors and actors. Thus, we need to find and address the key points where interventions can be most effective or most easily implemented and where behaviour change can truly become part of the solution and make a difference. Further, we need to discuss the situation in countries at all income levels – high-income countries as well as low- and middle-income countries (LMICs) – and with the potential need for different mitigation strategies.

The main focus of the workshop is on discussing possible behaviour modification interventions/actions to reduce the spread of antibiotics in the environment; an additional focus is on producing a 'call to action' or a prioritized list of recommendations for necessary behaviour changes. This list could include behaviours related to everything from production of antibiotics use of antibiotics, disposal of antibiotics, discharge of antibiotics from municipal, hospital, and industrial effluent, effective solutions for wastewater treatment, and monitoring/surveillance programmes. Actions are needed at all phases and in relation to all aspects and actors, from legislation to producers, professionals, and consumer behaviour modification. Below are some examples of questions to be discussed during the workshop:

- Who are the key actors in promoting and facilitating behaviour change at the local, national, regional and global/international level?
- What behaviours are possible to change in the short term and in the long term? What are the 'low-hanging' fruits?
- How and in what order should different behaviours be addressed? Or can different behaviours be addressed jointly and simultaneously, through multi- or transdisciplinary collaborative efforts?
- Where are the bottlenecks in changing the different behaviours?
- How can behavioural change be managed on the ground or in practice?
- Who will pay for these efforts?

Background to the workshop topic

Antibiotics are one of the more common classes of medications; they are used in human health, animal health, agriculture and aquaculture as well as elsewhere in various types of production processes (WHO, 2010, 2018). Rational or appropriate use of antibiotics is commonly addressed in relation to behaviour modification in health systems. Less frequently addressed is the appropriate disposal of unused antibiotics, the above-mentioned discharge of antibiotics in effluent or what is actually happening with the huge amounts of antibiotics that are excreted into the environment after use by humans and animals.

The Global Action Plan on antimicrobial resistance (GAP)[1] emphasizes the "One Health" approach, i.e., seeing humans, animals, the food chain, the environment and the interconnectedness between them as one entity.

There is a range of key actors relevant to the topic of this workshop. They are, e.g., legislators/policymakers/governmental agencies, venture capitalists, industry (producers of substances, formulated medicines, diagnostics as well as producers of meat and water for sale, including bottled water), international organizations, health care producers (health centres, hospitals, nursing homes, etc.) and professionals, e.g., prescribers for humans as well as animals, dispensers, pharmacy organizations, consumers, persons responsible for wastewater treatment, risk assessors, etc. – in sum, more or less everyone in society.

In the following sections, some areas in which behaviour modification will be needed to reduce antibiotic residues in the environment are briefly discussed. This is by no means a comprehensive review, but just a presentation of examples related to the different aspects, including some potential behaviour modification recommendations.

Production of antibiotics

Pharmaceutical plants can release large amounts of antibiotics into the environment. One study estimated antibiotic release in kilograms every day (several tons yearly) from only one cluster of Indian pharmaceutical industries (Larsson et al., 2007). There are several such clusters in India and Bangladesh alone.

Antibiotic use

Antibiotic use for humans is high, increasing or expected to increase in many countries globally (van Boeckel et al., 2014), although in some countries like Sweden, it is decreasing.[2]

Let us assume that 20% of the population takes one course of antibiotics a year (it is lower in Sweden, but higher in many countries), and that each antibiotic course consists of 1500 mg a day. As an example, in the South East Asia region (SEAR), that would amount to 380 million people taking one antibiotic course a year. It is estimated that about 50%–90% of consumed antibiotics are released unmetabolized or in biologically active forms in excretion, which means that only considering human consumption, about 500 tons/year or more than 1 ton/day of antibiotics would be released into the environment in the SEAR. Added to that is animal use, which is estimated to result in roughly similar quantities. Thus, human and animal use together could be adding about 1000 tons of antibiotic residues to the environment every year in the SEAR alone.

Disposal of antibiotics or waste containing antibiotics

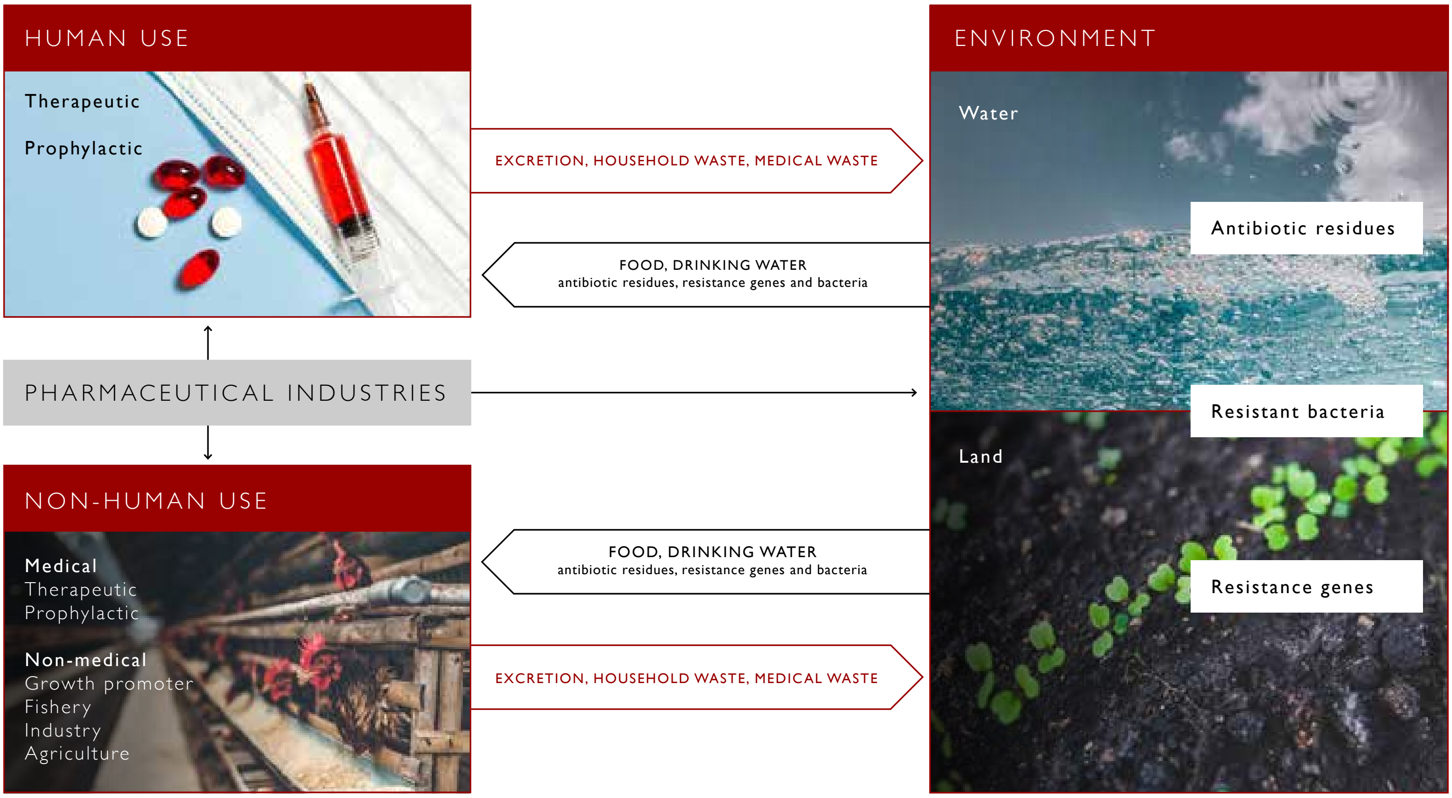
Consumers in many countries are accustomed to disposing of unwanted and expired antibiotics through household waste and sewers. Such disposal practices release antibiotics into the environment, wastewater and water sources. For this reason, there is a need to raise public awareness and encourage consumers to adopt sustainable practices for disposing of unwanted pharmaceuticals. In Australia, the RUM Project focuses on raising consumer awareness to inform consumers about the appropriate way to dispose of medicines.

In Sweden, in addition to the regular collection of unused medicines that has long taken place at all pharmacies as part of the national medicine strategy, special campaigns have been conducted during certain months to reach the goal of 80% return of unused medicines.[3] Special campaigns have also been used by various pharmacy chains, e.g., giving special bonus points to customers who return unsuded medications. This

1 http://www.wpro.who.int/entity/drug_resistance/resources/global_action_plan_eng.pdf.

2 Swedres, 2019, https://www.folkhalsomyndigheten.se/contentassets/fb80663bc7c94d678be785e3360917d1/swedres-svarm-2019.pdf.

3 Medical Products Agency, https://lakemedelsverket.se/english/



Potential routes of creation of antibiotic residues in the environment and transmission to and from the environment of antibiotic residues, antibiotic resistant bacteria, and antibiotic resistance genes.

kind of "take-back" programme exists in some countries, but seldom or never in LMICs.

Moreover, health care facilities dispose of antibiotics, and this might be done in general waste or in sinks if no facilities are available for collection or return of unused antibiotics.

Antibiotic residues and antibiotic resistance in wastewater

Antibiotics like fluoroquinolones and sulphonamides are chemically stable. Their residues are often detected in the environment, and resistance to them is commonly reported (Kummerer, 2009). Beta-lactam antibiotics produce easily degradable residues that are not easily detected, but that nonetheless contribute to resistance. Identification of a complete sequence of antibiotic resistance genes from soil bacteria and clinical pathogens has demonstrated the potential for horizontal gene transfer between environmental antibiotic resistant bacteria and pathogenic bacteria.

Hospital, municipal and industrial wastewater contains antibiotic residues and antibiotic resistance, and studies from Asia, e.g., India (Diwan et al., 2013), have reported residues of several antibiotics in hospital wastewater: e.g., up to 240 µg/L of ciprofloxacin, 80 µg/L of sulfametoxazole. The SEAR of the World Health Organization, to which India belongs, has about 2,090,000 hospital beds, and each hospital bed is estimated to require 400 litres of water a day; so, for only these two antibiotics, the residues will be about 250 kg/day. Besides the two above, many other antibiotics are used in hospitals. A conservative estimate of residues for all of the antibiotics used in all of the hospitals in the region would be 500 kg or a half ton/day, i.e., 183 tons of antibiotic residues a year. However, it must also be remembered that about 80% of antibiotics in human use are used by out-patients (European Union, 90%) (Stålsby Lundborg & Tamhankar, 2017).

Antibiotic residues and antibiotic resistance in other waters

High concentrations of antibiotics including flouroquinolones in surface, ground, and drinking water have been reported from Hyderabad, India, and the study suggested that the area in the vicinity of pharmaceutical plants was highly prone to antibiotic contamination, especially when wastewater treatment plants are inefficient (Fick et al., 2009). Detection of antibiotic residues in tap/drinking water impacted by wastewater discharge has also been reported in Asian countries (Leung et al., 2013; Sharma et al., 2019; Hanna et al., 2018). For example, flouroquinolones, including ciprofloxacin, were reported at high concentration in tap/drinking waters in China (Chen et al., 2018; Meng et al., 2019).

Antibiotic residues have already entered the major sources of drinking water for most people, and the occurrence of such residues may be persistent for several months and may not be completely removed through use of traditional disinfection technologies.

Wastewater treatment

It must be noted that, even in Europe and Australia, significant levels of antibiotics have been detected in effluents from treatment plants, indicating that the current technology does not eliminate antibiotics completely. The situation is worse in many LMICs, e.g., in South East Asia, where up to 80% of wastewater is not treated and contaminates ground water, surface waters, soils and even crops. Innovations and implementation should target efficient and affordable technology to remove antibiotic residues and resistant bacteria, preferably at the point of origin. Wastewater treatment plants may also act as hotspots for antibiotic resistant bacteria (Rizzo et al., 2013).

Photocatalysis (i.e., employing a substance to accelerate a chemical reaction process in the presence of light) using various types of light, such as solar or UV or LED, is a promising method for disinfection of bacteria and decontamination of antibiotics (Das et al., 2018).

Antibiotics in the environment: Risks and risk assessment

Besides risks related to antibiotic resistance, antibiotic residues could lead to other risks. Antibiotic residues could interact with the human microbiome. In this connection, one hypothesis has been put forward suggesting that, during the course of antibiotic treatment or through human exposure to antibiotics via drinking water and food, the groups of bacteria that were low in number and vulnerable to antibiotics could be lost, in contrast to the antibiotic resistant bacteria that would survive. If the bacteria influenced have special metabolic functions, the collateral damage to the host might lead to human metabolic perturbations and alteration of immunologic development, which may cause obesity and affect bone growth (Ashbolt et al., 2013; Ben et al., 2019)

Antibiotic resistance poses risks to human health, and there are concerns about the role antibiotic residues in the environment may play in the selection and spread of antibiotic resistance. Examining measured concentrations of antibiotics in aquatic environments where resistance could develop has recently been emphasized as a critical research need if we are to define risks to the environment and public health

Antibiotic residues and the sustainable development goals

Antibiotic residues and antibiotic resistance in the environment can threaten or have negative consequences for many of the sustainable development goals (Jasovský et al., 2016). Some examples are that antibiotic residues and antibiotic resistance in the environment directly influence Goal 1 (no poverty) and indirectly influence Goal 2 (zero hunger), as infections with resistant bacteria will result in high treatment costs and, thus, reduce the available funds. They directly influence Goal 3 (good health and well-being). Goal 6 (clean water and sanitation) is directly influenced by antibiotic residues and antibiotic resistant bacteria in the environment. Innovations are needed in the area of antibiotic residues and antibiotic resistant bacteria in the environment, thus involving Goal 9. Goal 14 and 15 (life below water and on land) are directly influenced by antibiotic residues and antibiotic resistant bacteria in the environment.

Desired outcome of the workshop

To produce a 'Call to action' or a prioritized list of recommendations for behaviour change (behaviour modification) interventions that could reduce antibiotic residues and antibiotic resistant bacteria and resistance genes in the environment. These behaviour modification interventions could be directed towards various actors and suitable to implement in different contexts.

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Workshop E

Making sense of antibiotic resistance

Communicate for behaviour change

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Aim of the Workshop

Although the looming crisis of antibiotic resistance is well understood scientifically, the response thus far has not been proportional to the scale of the problem. This is partly due to a failure in communication. The slow-moving nature of the problem poses a challenge in communicating its urgency, and the multifactorial nature of the issue necessitates a complex communications response. The shortcomings of antibiotic resistance communication are to some extent caused by a tendency to rely on technical and often aggressive language as well as by not sufficiently tailoring messages to all relevant contexts and stakeholders.

The aim of this workshop is both to encourage interaction between different disciplines and professional groups and to advance the discussion on effective communication tactics and messaging concerning antibiotic resistance. The workshop will bring together experts on communication, social science and antibiotic resistance to explore how communication can support changes in habits and attitudes. Drawing on principles of behaviour change communication, we will explore ways to create narratives as well as to tailor and deliver messages to different target groups.

After an inspirational introduction, the workshop participants will discuss and work collectively to develop communication messages and/or tactics for a set of predefined scenarios related to antibiotic use and resistance.

Expected outcomes of the workshop

- Development of a more comprehensive understanding of the concepts of behaviour change communication among the participants as well as the organizations and countries they represent.
- Advancement of the discussion on effective communication tactics and messaging regarding antibiotic resistance.
- Development of a set of communication messages or tactics for specific scenarios of relevance to antibiotic resistance.

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Slow moving but urgent – the challenge of communicating antibiotic resistance

Several factors affect the way we think about a problem, and therefore, also how we act. In the case of antibiotic resistance, several things stand out as particularly challenging from a communication perspective.

First, antibiotic resistance is perceived to be a slowly growing threat. We know that pathogens are developing resistance to existing antibiotics and that people are dying as a result right now, but the rate of this development is slower than that of a faster moving pandemic, such as Covid-19, and the extent of it is not completely known. Moreover, we have yet to adjust to that the current situation is more vulnerable than before. In the past, new types of antibiotics used to emerge on the market, thus replacing the loss of antibiotics that were no longer effective due to resistance. This is no longer the case, which means that although the ramifications of antibiotic resistance are more severe and more urgent than ever before, it is still seen as a problem for the future that does not need to be dealt with right now.

Second, managing antibiotic resistance requires that we make a lasting change in our behaviour, both as individuals and as communities – something that is intrinsically difficult. It is a large, multifaceted and global problem that will require larger systemic changes that go beyond individual action. This makes it impossible to devise a single solution. It also makes it difficult for individuals to feel their actions can lead to meaningful change, making it easier to block it out rather than to take action – "what does it matter if I do something small?"

Third, given the complexity of the problem and the many different levels at which change has to occur, it is imperative that communication efforts target the relevant stakeholders. This requires specifically addressing the motivation and possibilities for action of each respective target group. One size does not fit all.

Even though there are and have been many awareness-raising campaigns on antibiotic resistance, their impact is not completely known. It is difficult to evaluate the effect of a specific campaign for several reasons. For example, it is hard to define solid metrics with which to measure change. Even a successful campaign might not show results until later on as a situation that requires a changed behaviour may only emerge long after the campaign itself, making it difficult to define in which time frame the success of a campaign should be measured. Additionally, these campaigns are often part of bigger efforts and/or are simultaneously ongoing with other interventions, making it difficult to attribute a noticeable effect to one specific communication campaign or specific target group.

Communication for behaviour change

Behaviour change communication is based on the idea that human behaviour is influenced at the levels of the individual, the family and peer network as well as the level of society. The factors that drive change include knowledge, motivation, ability to act, and social norms. For a communication campaign to succeed, you first need to understand how each factor impacts each level. For example, how you educate an individual is not the same way you educate a group of people, and how you motivate a society to change is not dictated by the same drivers that would motivate a family unit.

Individuals may consider their personal gain, and a small network what is best for the people they care about who are closest to them. At the societal level, you are asking people to take action that may have little direct impact on them and their peers, but is beneficial to society as a whole.

To create change, each change-inducing factor needs to be applied to each level. The individual will be impacted by a combination of acquiring the right knowledge, becoming motivated, enabled to act, and conforming to social norms. The same is true of the peer network level and societal level – each of which requires an adjustment to how the factors are applied.

At an individual level, knowledge is a powerful factor to change behaviour: *I limit my use of antibiotics because I know that using them can be directly harmful to my health, and there is a real risk that antibiotics will not work for me in the future.* But at a societal level, it is challenging to motivate people to do what is best for complete strangers, or for unknown future generations. In some instances, establishing new norms might be the most powerful way forward: *The excessive use of antibiotics is frowned upon in my community, so I limit my use of antibiotics because I want to conform with the norm.*

Moreover, it's crucial to remember that merely conveying information from one party to another is not the same as successful communication. The latter implies that the information has also been received and understood by the audience, which can only be gauged by following up with the audience to check how much of the information they retained. Messages normally have to be repeated several times and from different sources before an idea really sticks with the audience. Different tactics are routinely employed to get the target audience to pay attention, such as using humour or nostalgia to invoke an emotional response, or embedding a message in a story-driven narrative that provides the audience with an easy-to-remember context.

Given that in many cases, particularly in resource-limited settings, it may not be possible to act on the recommendations provided, it is not feasible to place all of the responsibility for change on the individual. Thus, for communication campaigns on antibiotic resistance to be successful, it is important to consider cultural contexts, what types of knowledge, expertise and channels are trusted to reach different target groups, as well as to test the messages among the intended target populations. And as emphasized by the WHO World Antibiotic Awareness Week campaign: "although raising individuals' awareness of antibiotics and resistance is important, the campaign recognizes that real and actionable change happens when communities everywhere become engaged."

Managing antibiotic resistance require that we make a lasting change in our behaviours, both as individuals and as communities.

Creating paths for change

Communication and awareness-raising are crucial to bringing about large-scale change and the will to change. But equally important is the creation of structures that support the desired behaviour and clear the path for new habits, because without the necessary logistics and options in place to make the "right" choice, it matters little how well-informed an individual is. In human health, such a structure could be to make diagnostics available to allow the right treatment choice, and in animal health it might involve offering support for improving hygiene and husbandry practices in farms that can replace routine use of antibiotics in livestock.

This will require political action to: invest funding in actions such as educating stakeholders in the healthcare sector and in farming, offer financial compensation to those who have to establish new practices to replace excessive use of antibiotics as well as make alternative treatments or methods readily available.

Increased knowledge or awareness does not automatically translate to desired actions or behaviours. It is thus important to consider what behaviours one wishes to change with a campaign and whether the structures are in place to enable that change, as well as to deal with any potential unintended consequences. Continuously reviewing the results of a communication campaign is crucial, as it identifies unintended consequences and obstacles, and allows for adjustments that could result in more effective campaigns. To give a more specific example, an antibiotic-related communication intervention based on awareness-raising materials from the World Health Organization in three villages in Thailand found that, although participants aligned with the recommendations provided, the fragmented availability of healthcare to some extent limited their ability to act on these recommendations – the structures for change were simply not available (Charoenboon *et al.,* 2019). The intervention also brought with it a negative unintended result: One participant started to sell antibiotics because she felt educated enough to take on the task.

Another potential unintended result is the possible stigmatization of certain groups, as demonstrated by a case in Denmark. Although the country is internationally known for fairly low usage of antibiotics in pig farming, a heightened awareness of the risks associated with antibiotics in farming linked to overrepresentation of pig farmers as carriers of MRSA has resulted in pig farmers being publicly exposed as irresponsible users of antibiotics, with stigmatization as a result (Fynbo *et al.*, 2018).

How should we improve communication about antibiotic resistance?

Communications, messaging and media coverage on antibiotic resistance today commonly rely on the use of scare tactics and war metaphors. This attracts attention, but is known to be inefficient from a behavioural change perspective, as it easily wears out the recipient and causes "deflection of the problem". Moreover, it is problematic from the perspective of creating an often misplaced fear of microbes. Other problems with how antibiotic resistance is currently communicated extend to: the number of different terms used, for example, "drug resistance", "antibiotic resistance", "antimicrobial resistance" and "superbugs"; the multiple frames presented, such as different impact frames on death, economy, or healthcare; the uneven media coverage; and the lack of a mainstream conversation about the topic (Capurro, 2020; Krockow, 2020; Wellcome, 2019). Additionally, it has been proposed that the current scientific discourse on antibiotic resistance causes the public to feel powerless to take action and unable to be part of the solution (Davis et al., 2020).

Recent research (Wellcome, 2019) points out that, in order to increase public comprehension and persuade the public and policymakers to make behaviour changes and take action, five main principles can be applied that lead to better communication about antibiotic resistance. These five principles focus on:

1. Framing resistance as undermining modern medicine.
2. Explaining the fundamentals in a simple and straightforward manner.
3. Emphasizing that it is a problem that affects everyone.
4. Focusing the messages on the here and now.
5. Encouraging immediate action that is within the intended audience's means.

These principles highlight the need to frame the problem as a current, relevant and actionable issue for the target audience. It is of special importance to communicate what actions can be taken now to stimulate behaviour change. For this reason, broad global campaigns without a narrow targeted audience may not work as well for this purpose (Huttner, 2019).

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Interactions between patients and health-care workers are important for proper antibiotic use. Efforts to change social norms and to increase patient--doctor trust can be efficient pathways to change.

Workshop F

When children relate to the 'wild'

Potentials benefits and perils in human-animal learning encounters

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Aim of the workshop
Practices involving encounters between humans and animals can be manifested in various ways. From the everyday practices of children living with and tending to animals in their homes to planned educational activities in which children visit animals at farms, research has indicated that human-animal encounters can promote learning among both adult and children. Meanwhile, such encounters also involve the perils of exposure to infection and the transmission of resistant genes between humans and animals. These perils represent the 'wild' of zoonosis and antimicrobial resistance (AMR), highlighting our limited ability to control all aspects of human-animal encounters. To realize the learning benefits of human-animal encounters, there is a need to account for ongoing microbial processes.

The workshop aims to draw on participants' experiences to explore how we can address both the potential benefits and the perils of human-animal encounters, especially for children.

The workshop offers participants an opportunity to:

1. Reflect on their past experiences of animal proximal practices from the perspective of potential benefits and perils and
2. Develop a vision and action plan concerning how we can facilitate children's human-animal encounters, harnessing their learning potential while addressing the 'wild' of zoonosis and AMR.

People and their livestock in a village near Ngorongoro Crater, Tanzania

The focus of the workshop

The workshop aim, as outlined above, can be understood in relation to the body of research that has primarily focused on the perils of human-animal encounters. As such, guidelines have often been outlined to mitigate these risks without fully considering the learning potential. Meanwhile, the question remains of how we can make this information relevant over time to the specific animal proximal practices and the children, regardless of whether they occasionally visit or live with animals in their everyday lives.

Furthermore, what opportunities do we have to 'inform' about the perils, while not undermining potentials for learning and promotion of well-being in human-animal encounters?

We argue that there is a need to involve practitioners as well as would-be visitors and learners in organizing human-animal encounters. Such efforts would help us find ways to harness the potential benefits of human-animal encounters while addressing the possible risks. Naturally, which children will be involved depends on whether the practices discussed are children's on-going everyday practices or the practices of children who visit animals, whether in the global south or the global north.

As such, the workshop involves two focus areas of investigation:

- What are the potentially beneficial and perilous conditions for encounters between children and animals as part of animal proximal practices?
- How can the planning and organization of human-animal encounters be contextually adapted so as to enable children to learn, while mitigating the risk of resistant microbes through zoonosis?

In line with the purpose and focus areas of the workshop, we will enable participants to develop their ability to create understandings (meaning-making) of health-related information, to critically evaluate health-related information and to take conscious health-related decisions and actions.

The workshop will take its starting point in participants' past experiences and progress, ranging from developing contextually relevant understandings of health-related information,

Children's interactions with animals provide many important benefits. How to effectively communicate about infectious disease risk in these encounters without undermining their potential, is an important area for discussion and learning.

through developing criteria for critically evaluating health-related information, to formulating visions and action plans for taking conscious health-related decisions and actions.

The resulting action plan(s) can help practitioners, teachers, educators in informal education, policymakers, politicians, and others to bridge the implementation gap between health-related 'information' and health-promoting practices. As such, the workshop offers participants opportunities to explore the potential of children's learning encounters with animals, while consciously addressing the perils that such encounters involve in relation to the 'wild', i.e. not fully controllable, aspects of zoonotic diseases and AMR.

As highlighted by Conrad et al. (2018), significant educational opportunities are provided by petting zoos and agricultural fairs – places where children and adults can interact with and learn about farm animals. Meanwhile, these encounters present significant human exposure to zoonotic pathogens and AMR. In their study, Conrad et al. (2018) concluded that zoonotic pathogens and AMR were clearly present within the studied animals and their environment. The identified pathogens could potentially cause both mild and severe illnesses.

The workshop

The workshop will take the form of learning encounters between the participants, health-related information (specifically AMR), and participants' experiences. The workshop will progress from participants developing contextually relevant understandings of health-related information and criteria for critically evaluating health-related information, to formulating visions and action plans for taking conscious health-related decisions.

The workshop will include three parts, including short lectures/presentations and workshop sessions. Part I of the workshop focuses on 'information' regarding the potential benefits and perils of children's human-animal encounters. Part II centres on how the 'information' has been used in various practical implementations and examples. The workshop session addresses Aspect II, how the 'information' can be critically evaluated, using a number of example scenarios. Finally, Part III addresses Aspect III (health literacy), emphasizing learning encounters between humans and animals. Additionally, efforts to create conditions for learning that emphasize the potential benefits and perils of such encounters are considered. As part of the workshop session, participants will envision their own implementation and adaptation of the 'information' presented during the workshop. Resulting from our workshop, participants will have co-created knowledge regarding the potential benefits and perils of human-animal encounters as well as how this knowledge can be related to their past, present and future practices.

While the research has offered a range of definitions, health literacy can be described as the ability to understand as well as critically evaluate health-related information, further enabling conscious health-related decisions to be taken (Nutbeam D, 2008; Sørensen et al., 2012; Ward M. et al., 2019). Health literacy presents a conceptual avenue for exploring the relationship between education and health and offers a way to bridge the 'implementation gap' between knowledge about health and health-promoting practices (Van der Heide et al., 2013).

As concerns educational research on AMR as a sustainability challenge, the emphasis on health literacy suggests exciting parallels to the work that has been done in and on science literacy, especially related to climate change as a sustainability challenge.

Moreover, health literacy is not limited to developing knowledge, but also concerns facilitating the development of people's capacities and improved empowerment with regard to health issues, whether these issues affect them personally or their social and natural environments, including both animals in food production and animals in the wild.

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Workshop G

Where are our antibiotics?

Three possible solutions to addressing antibiotics shortages and improving antibiotics supply globally

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Antibiotics are a cornerstone of modern medicine, and yet access to established antibiotics is a major problem across the globe. There are both occasional shortages of old generic products either locally or globally, as occurred in 2017 with piperacillin-tazobactam, and sudden withdrawals from markets, as occurred in 2016 with ceftibuten. Moreover, many other antibiotics are not registered and supplied at all in markets considered economically unattractive, such as low-income countries. When these antibiotics are not available, patients are exposed to unnecessary suffering, healthcare costs surge and antibiotic resistance accelerates because suboptimal antibiotics have to be used in the place of better options.

Aim of the workshop

Why do antibiotics shortages occur? And what solutions can be introduced to avoid these shortages? These questions are discussed in this workshop, with a specific focus on three potential solutions: (1) *more transparent supply chains*, (2) *improved profitability for antibiotics suppliers* and (3) *upgraded production systems*. The workshop will also address the need for greater collaboration among the various stakeholders involved in the antibiotics field, relying on the experience of, for instance, the Swedish collaboration platform PLATINEA (www.platinea.se).

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The phenomenon of drug and antibiotics shortages is not new, it has been slowly increasing over the past 10 years, and antimicrobials are among the drugs most often in shortage across Europe.

Background

The Covid-19 epidemic has brought to the fore the key problem of drug shortages, as demand for such medicines as painkillers, anaesthetics and some classes of antibiotics peaked while supply was disrupted globally; there were even countries that introduced export restrictions on active pharmaceutical ingredients (API) and final products (Chatterjee, 2020). However, the phenomenon of drug and especially antibiotics shortages is not new. Rather it has been slowly increasing over the past 10 years or so (OECD, 2020), and antimicrobials are among the drugs most often in shortage across Europe (Miljković et al., 2019). Other high-income countries, including the US, are also regularly and increasingly being hit by antibiotics shortages (Quadri et al., 2015; US FDA, 2019), not to mention the notoriously poor access to essential antibiotics experienced in low- and medium-income countries, as these products have never been registered in these markets (Pulcini et al., 2018; Tängdén et al., 2019).

Recently, there have also been cases of global antibiotics shortages: Ceftibuten was withdrawn from most markets in 2016 due to difficulties in transferring production to a new facility; in 2017, there was a long-term shortage of piperacillin-tazobactam due to repeated accidents in the core API production facility in China; benzathine penicillin, one of the most common and inexpensive antibiotics, was unavailable in 2015 in almost 40 countries (Nurse-Findlay et al., 2017) due to insufficient production capacity at too few API producers (Cogan et al., 2018).

Costs and other negative consequences of antibiotics shortages

Drug shortages entail costs and negative consequences, which are particularly serious in the case of antibiotics due to indirect effects on antimicrobial resistance (AMR) (ReAct, 2020). While in modern healthcare systems an antibiotics shortage typically causes additional costs for replacements in modern healthcare systems, in places where there are no alternatives, like in low-income countries, the extreme consequence is increased mortality. Assessing the costs of shortages is extremely complex, but estimates made by some countries indicate USD 20–30 million per antibiotics shortage (WHO, 2019). These costs include the direct fixed administrative cost of identifying, deciding on and procuring alternative antibiotics, as well as the variable cost of purchasing possibly more expensive antibiotics, depending on the country and patient population size (cf. Miljković et al., 2019). To these direct costs one should also add indirect costs related to longer hospitalization, increased morbidity and even mortality in situations where alternative therapies are not available. Unfortunately, it is estimated that between 450,000 and 800,000 children under the age of five die of pneumonia annually owing to lack of access to antibiotics (ReAct, 2020; Stoppneumonia, 2020), and here we are talking about a standard, simple antibiotic treatment that would cost only 40–50 US cents.

Moreover, antibiotics shortages cause a series of other negative consequences that impact on AMR. Not receiving the right antibiotic means that patients get a suboptimal antibiotic with potentially poorer effect and greater risk of side effects, possibly leading to development of more resistance (ReAct, 2020). These outcomes are particularly likely when a narrower spectrum antibiotic is in shortage and must be replaced with a broader spectrum one, causing not only resistance development among more bacteria, but also negative effects on the patient's microbiome. Further, when the antibiotic of first choice is unavailable, it may be replaced with "reserve" antibiotics, which should preferably be used more sparingly to maintain their efficacy against more aggressive or resistant bacteria. This means that the power of antibiotics that constitute our last lines of defence, such as colistin and meropenem, is unnecessarily reduced. Finally, antibiotics shortages open a door to dishonest players who sell expired products without authorizations or entirely counterfeit products, which can again cause adverse reactions or be of such low concentration that they obstruct treatment or accelerate resistance (ReAct, 2020).

The causes of antibiotics shortages

Considering the immense therapeutic value of antibiotics, how is it possible that shortages occur, and are even occurring at an increasing rate? What are the reasons for these shortages? It is possible to trace a particular shortage event to, for instance, a sudden surge in demand that could not be met with timely orders, to disasters or accidents, discontinued production or quality problems in production, with the latter accounting for over 60% of shortage events (US FDA, 2019; OECD, 2020). However, behind the reasons for a single antibiotics shortage event, there is a set of complex *root causes* at play, most of which concern economic and profitability issues (WHO, 2019; US FDA, 2019) related to the entire antibiotics field, from supply sectors such as API all the way to end markets. One overarching problem is that most antibiotics are "generics" (Cogan et al., 2018), that is, have lost exclusivity and are open to intense competition, which makes their price fall to the direct advantage of consumers, but which also reduces their profit margins to a point where suppliers may eventually lose the economic motivation to make them available.

The general problem of low profitability in this field can be further broken down into several specific causes, which in turn generate numerous effects that further aggravate the problem of antibiotics shortages. For instance, the Swedish multi-sectorial collaboration platform PLATINEA has identified no fewer than 60 such specific causes. Some of these causes concern the *buyer side*, such as procurement models causing price races "to the bottom" (US FDA, 2019; WHO, 2019), the absence of volume commitment through long-term contracts or strong fluctuations in local demand (Cogan et al., 2018), which result in both *low profit per unit* and *uncertainty about volumes* – two factors that, if they occur simultaneously, have a strong negative effect on antibiotics providers. This problem is aggravated by *manufacturing side* causes: The antibiotics production system is rigid, that is, not flexible enough to cope with the aforementioned uncertainty, due to both regulatory constraints (e.g., moving old products from one plant to another) and technical constraints, with plants operating close to full capacity, but facing costs of building a new plant that exceed USD 100 million (US FDA, 2019). This is a much-needed investment, as many facilities need modernization and upgrading when confronted by, among other things, stricter environmental requirements, but it is also a problematic investment when profitability is so low.

Rewarding suppliers that offer high manufacturing quality and delivery precision, or increasing transparency across supply chains are among the possible solutions for antibiotic shortages.

As a reaction to these challenges on both the buyer and manufacturing side, as well as to the pressure to constantly reduce prices, many antibiotics providers have opted to offshore the production of API to remote locations, which in turn results in shortages caused by the *supply sector side*: The number of API suppliers has decreased, and they are concentrated geographically in a few locations in China and India (WHO, 2019; Huq et al., 2016), which exposes the supply of antibiotics to disaster risk as well as to geopolitical and global trade risks. Pollution and discharge of wastewater accelerating AMR locally are other risks associated with this geographic pattern (Bengtsson-Palme et al., 2014).

Moreover, these global supply chains, stretching across several countries, are longer and ultimately more fragile (US FDA, 2019; Cogan et al., 2018): Their fragmentation causes difficulties in communication and coordination of physical flows, which increase the risk of shortages. This problem is aggravated by yet another root cause, namely the *lack of transparency* concerning antibiotics supply chains (US FDA, 2019; WHO, 2019), because industrial players consider this information to be strictly confidential and sensitive owing to the impact it may have on competition. This approach reflects, in turn, a broader problem regarding the norms of the antibiotics field, namely *weak collaboration* between the various involved stakeholders, such as authorities, academia, industry and healthcare, who typically lack forums in which they can meet and discuss solutions to problems such as shortages.

Possible solutions to antibiotics shortages

Given the many causes mentioned above, several solutions have been proposed to address antibiotics shortages (OECD, 2020; US FDA, 2019; WHO, 2019; Cogan et al., 2018). Clearly, when a shortage occurs, it has to be handled immediately through, for instance, identification of alternative antibiotics or parallel imports (OECD, 2020). But it is even more important to prevent shortages from happening in the first place. Most of the preventive solutions involve innovative economic models and changed behaviours on the part of several actors in the entire antibiotics field. Some of these solutions operate in the short term, such as introducing early warning systems, improving stocks (acting as buffers against demand fluctuations) and improving demand forecasts as well as suppliers introducing risk management programmes (WHO, 2019; Cogan et al., 2018).

However, to justify major long-term efforts, it is pivotal to start by clearly quantifying the harms caused by antibiotics shortages, something that is currently lacking (US FDA, 2019) but that would show the benefits of such efforts. In particular, the proposed long-term solutions include the following: providing better financial incentives through additional rewards or alternative reimbursement models de-linked from sales volumes, such as those currently being piloted by Sweden and the UK (WHO, 2019); rewarding suppliers that offer high manufacturing quality and delivery precision (US FDA, 2019); capacity building and investments to strengthen key nodes in supply chains (Cogan et al., 2018); and increasing transparency across supply chains to allow all stakeholders to identify supply risks related to specific locations and plants (US FDA, 2019; WHO, 2019; Tängdén, 2018). Another important solution to avoid dependence on single actors is "multiple sourcing" in various steps of the supply chain (Cogan et al., 2018), starting from public tenders that, instead of the current "winner-takes-all" approach, split allocations among several suppliers (WHO, 2019). One positive side effect of multiple-winner tenders would be motivating more suppliers to remain on the market, as a way to preserve supply alternatives.

Looking even more specifically at the purchasing side, another relevant solution is joint procurement by the governments representing smaller or unattractive markets (OECD, 2020; Tängdén et al., 2018). Finally, an extreme measure to ensure supply is to stimulate local production of critically important antibiotics (WHO, 2019), even by relying on not-for-profit producers (OECD, 2020). All in all, there seems to be no scarcity of possible solutions to antibiotics shortages, but this workshop will focus on the following three solutions: (1) *increased transparency* of antibiotics supply chains; (2) *improved profitability* throughout the supply chain, starting from better reimbursement and certainty for suppliers (e.g., long-term contracts); two solutions that, in turn, are expected to (3) *enable investments in new and upgraded factories*, as a way to counteract the risks of adverse events such as production failures and environmental pollution. The discussion will focus on the pros and cons of these three solutions, as well as the possibilities and obstacles associated with introducing them.

International collaboration involving all stakeholders is another overarching solution to addressing drug shortages that has been proposed by, among others, the OECD (2020). Therefore, we will also take the opportunity to discuss the possibility of creating such collaboration by looking at the experience of the Swedish multi-sectorial collaboration platform PLATINEA, which involves academia, industry, healthcare and public authorities working together to develop solutions against antibiotics shortages (www.platinea.se).

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Workshop H

Teaching antimicrobial resistance

Educating young people to be change agents

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We want our children to have the benefit of growing up in a world where it is possible to cure common diseases, such as pneumonia or meningitis, successfully treat complex diseases such as cancer and to do surgery without imminent risk of incurable infection. Therefore, we need our children – the next generation of citizens – to feel competent, able and willing to contribute to the work of preserving the power of antibiotics as effective medicine for bacterial infections in humans and animals. If we are to give children the competence they need to take action to preserve antibiotics, it is not enough to teach them the medical or epidemiological facts; they also need to learn values and priorities associated with the emergence and spread of antimicrobial resistance (AMR) as well as to transform their knowledge and values into practical actions.

Aim of the workshop

In this workshop, we want to bring together a group of educators, curriculum experts, policymakers and health experts to discuss the role schools can play in giving young people the competence they need to act responsibly and preventively as well as to, when antibiotics are necessary, use them wisely. In addressing the multi-sectorial nature of AMR, there is a need for teaching that helps students pay attention to, and see connections between, the many concurrent perspectives of relevance: medical, ecological, technical, ethical, social and economic perspectives. With this in mind, we would like the workshop to address, in particular, what education should include if it is to produce students who can act competently in relation to AMR issues, and how this competence is best taught in the context of a formal education system. The workshop discussion will be guided by the following questions:

- What does teaching need to address, including both facts and values, to educate students and ensure their competence and willingness to act in relation to AMR issues?
- How can we work to enable teachers to feel confident about teaching issues of high complexity, including multiple perspectives and, at times, conflicting interests and needs?
- How is it possible to teach about a topic that may have very severe consequences without students becoming scared or disillusioned about the future?
- How do we work to accumulate, sustain and disseminate experiences of and build a knowledge base around teaching about AMR?

Habits are something we learn early. Formal education provides a potential to influence them in a positive direction.

Situating education

Establishing effective education in AMR has been highlighted as a high priority area, both in the UN Sustainable Development Goals (UN, 2015, §26) and in the WHO Global Action Plan for Antimicrobial Resistance (WHO, 2015). Education is seen as crucial to creating awareness of AMR and increasing people's opportunities to develop responsible habits.

Children spend much of their day at school, and given that good habits are established early in life, schools could have an important role to play in promoting better understanding, awareness and action competencies in relation to AMR. Schools in most countries reach all children regardless of their socio-economic situation, gender and ethnicity, and if parents and relatives also get involved, a large proportion of the population will be reached.

Getting people to change their behaviour involves learning new habits, including knowledge and values, as well as acquiring the skills needed to transform their knowledge and values into making new priorities and creating new behaviour patterns. In teaching, there are opportunities to introduce and discuss the issues of values and priorities regarding the use and overuse of antibiotics.

Designing lesson plans always involves selecting what content to include and what methods to use in conveying this content. These choices must be made with regard both to students' prior knowledge and to their experiences, also considering the school system's regulations. This situation poses a challenge to schools and teachers, especially because the schools must educate both students who are considering a career in science and students who will use their scientific knowledge in everyday life.

Challenges for education

The responsibility for addressing the content of AMR, if it is addressed at all, frequently falls on the science teacher. Previous research has shown that teachers often find it difficult to teach about issues that concern questions for which a scientific answer is not sufficient (Zeidler et al., 2005). Teachers tend to hesitate to include content from different disciplines in their teaching. Apart from the difficulty of teaching subjects one does not fully master, teachers fear that their "own" subject content may suffer and that it will be hard to find relevant teaching material that integrate different subject areas in a productive way (e.g., Tytler, 2012).

The disciplinary components of AMR have also proven to be difficult to learn and master. Studies investigating AMR have shown that the majority of university-level students have misconceptions about AMR and often rather use intuitive reasoning to explain the evolutionary processes about AMR (e.g., Richard et al., 2017). At the lower secondary school level, reports on scores from national tests in Sweden have shown that items testing knowledge about AMR were very difficult for both high- and low-achieving students (Lind Pantzare et al., 2015). Thus, more research and development are needed concerning teaching and learning about AMR.

Perspectives from science education

On a general level, selecting what content should be included in science education has been described as a struggle between two approaches: Vision I and Vision II (Roberts, 2007). Simply put, Vision I is based on the belief that if one learns scientific facts and methods, one can automatically apply this knowledge when the situation requires. In Vision II, the argument is that the ability to apply scientific knowledge requires special knowledge, skills and values concerning how to apply this knowledge, and that acquiring them also requires a learning process. For example, involving students in decision-making also includes their learning competences, such as argumentation skills. In such situations, students must be able both to cope with disagreements and to put forward their own arguments in response to others' opinions.

In Vision II education, it is not enough for students to learn facts about AMR; teaching must also include practising how to apply scientific knowledge in authentic situations where evaluation of different options is necessary, enabling students to use this knowledge and act upon the issues at hand.

If students are to become "action competent", they must be given opportunities to practise multiple kinds of skills (e.g., Jensen & Schnack, 2006). Sass et al. (2020) discuss what characterizes an action-competent person. In their view, this person is devoted to and passionate about solving societal issues; he/she also has relevant knowledge about both the issue and the decision-making processes involved. Moreover, he/she is able to consider different perspectives, take a critical but positive stance on the issue at stake and has confidence in his/her ability to make a change for the better. This way of thinking about teaching AMR places great demands on the ability to weigh different considerations and critical thinking skills.

Action and innovations to support teaching

Regarding the educational research on AMR as a challenge to sustainability, there is a need for more knowledge about AMR in relation to teaching and learning in formal education, yet some studies have made important contributions. For example, Fridrichsen et al. (2016) presented a design case for teaching AMR in upper secondary school biology as well as the key challenges they have encountered in this work. Their ambition was to situate the content of AMR in a societal context, thereby engaging the students in examining the social aspects of the issue from multiple perspectives.

Additionally, there have been several national and international educational efforts to influence and support public knowledge about AMR. Such initiatives have typically been taken by authorities or organizations, aiming to inform and educate citizens. Some of the projects have been directly related to the curricula in a specific context and are, thereby, available for teachers to use. There has been a tendency in these efforts to assume there is a link between public awareness of, knowledge about or certain attitudes towards AMR and the propensity to act in what is often described as a 'rational' way. Still, the question remains as to whether and how more knowledge can lead to changes in behaviour.

The question of teaching and learning AMR in relation to behaviour change has not been addressed to a great extent, and we maintain that there is a need to further develop knowledge about how this can be done fruitfully in teaching. One major problem in education is that the teaching profession does not have established methods for professional knowledge exchange. If we could enable teachers around the world to share their lesson plans, teaching material, etc., with each other, time and money could be saved, while at the same time increasing the quality of teaching.

Students' interest in and engagement with the subject

One of the reasons for encouraging use of authentic problems and students' genuine participation in education is that this is one way to create engagement with an issue. Engagement with a subject can be achieved when participants feel an emotional connection to what is being discussed (Östman, van Poeck & Öhman, 2019). However, it may be challenging to encourage emotional attachment to a subject students have limited experience with. Research in the area of climate change education has shown that students experience feelings of anxiety, worry and helplessness, but also hope, when presented with future prospects (e.g., Ojala, 2016). Many times, worry is seen as wholly negative, as it distracts people from the essential question, makes them unreceptive to new information, and causes them to focus on their own self-interest, all of which prevent change. But Ojala argued, on the contrary, that recognizing and addressing these feelings may also be a driver of engagement. Such engagement can motivate students to acquire subject knowledge as well as to think critically, deliberate, engage in problem-solving and discover more sustainable habits.

How can we help schools and teachers plan AMR education that promotes action competence?

We live in a time with great local and global sustainability challenges – challenges for which there are no clear-cut solutions. In this text, we have highlighted the need to re-think traditional modes of teaching, which are often characterized by transferring an established set of facts about an issue. We argue that there is a need for citizens to have knowledge about AMR, but also the competence needed to act and change behaviour in relation to AMR issues, thus, to make a change. The question is: What can formal education do so that students will be able to contribute to preserving the effectiveness of antibiotics?

In this workshop, we wish to discuss how we can work to ensure that a diverse future generation has relevant knowledge about both the emergence and spread of AMR as well as about the decision-making processes involved. How can we see to it that this generation is committed to and passionate about solving the problem? How can we promote students' confidence in their own ability to make a change in the conditions that will shape the future? This challenge involves operationalizing and concretizing a form of teaching about AMR that enables this kind of learning.

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