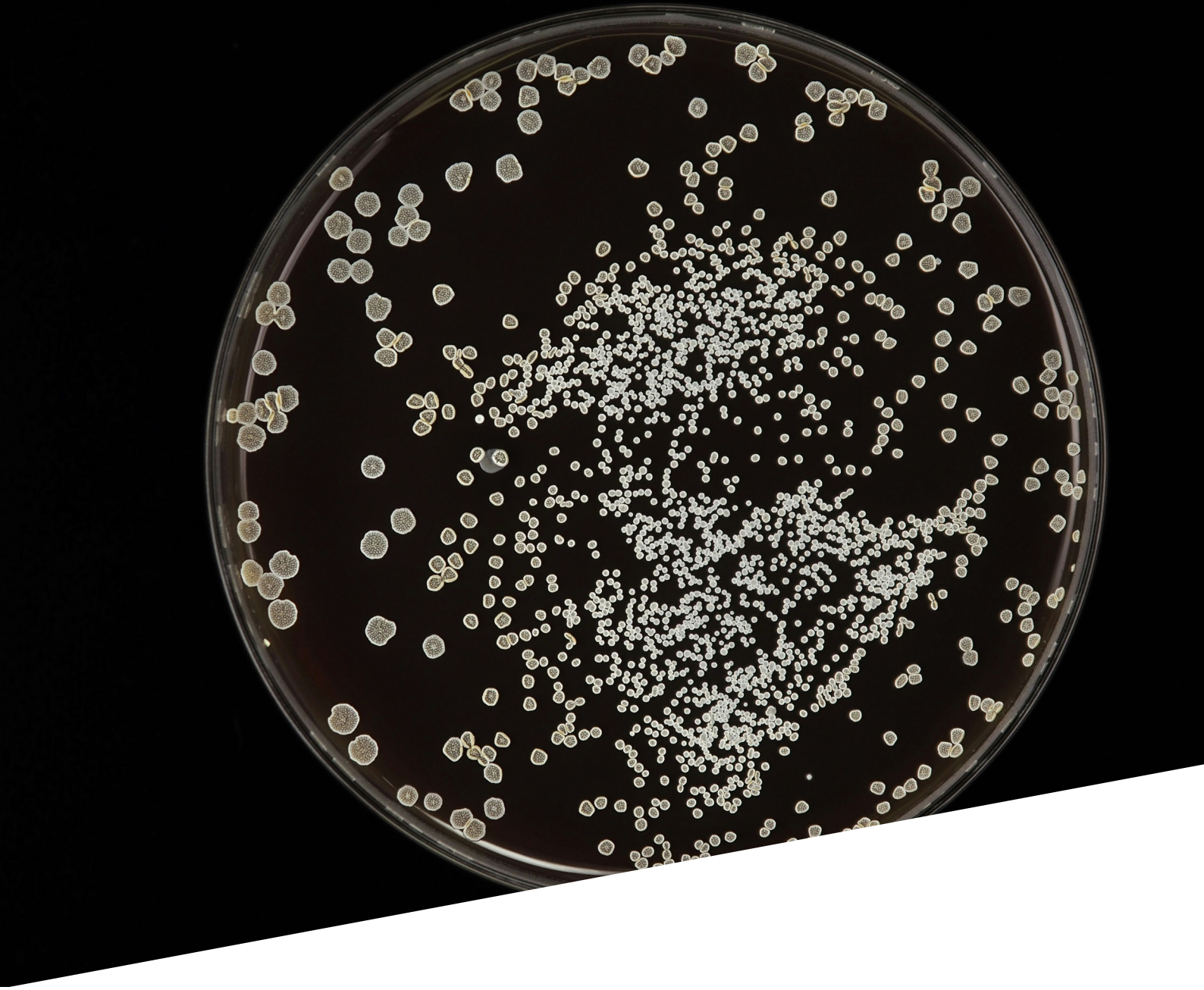


CENTRE FOR ANTIBIOTIC RESISTANCE RESEARCH IN GOTHENBURG

CARe

ANNUAL REPORT 2024

CHALMERS UNIVERSITY OF TECHNOLOGY | UNIVERSITY OF GOTHENBURG

CONTENT

WORDS FROM THE CENTRE DIRECTORS

The most important step in managing the global challenges with antibiotic resistance in 2024 was the political declaration on AMR, adopted by all 193 member states of the United Nations. The need for more research on new therapies, diagnostics, surveillance as well as preventive actions across the one-health spectrum is one of many messages to governments, industry, funders and universities globally.

CARe is expanding and now hosts 161 researchers from 19 departments. This probably makes us the broadest, most multidisciplinary research centre on antibiotic resistance in the world, placing us in a unique position to deliver new knowledge and solutions.

We acknowledge that our long-standing research has made a clear footprint in the UN declaration. We have also supported the Swedish government for more than two years in its preparation. Along the same lines, the first guideline from the World Health Organization on management of wastewater from antibiotic manufacturing was launched in 2024, where we also contributed significantly. Both of these examples illustrate how curiosity-driven research eventually can lead to global impact. It also emphasizes the value of providing knowledge support to policymakers.

We thank the Sahlgrenska academy and the Faculty of Science at the University of Gothenburg, Chalmers University of Technology, Region Västra Götaland, and the Sahlgrenska University Hospital for their support. We are particularly happy for the new collaborative work between CARe, the Region Västra Götaland and the six largest regional hospitals in investigating risks for antibiotic resistance development in their sewers.

This report illustrates some of our recent achievements, including stakeholder workshops and several large research grants that pave the way for important research in the years to come. As director and co-director, we are grateful for the confidence given to help developing CARe further.

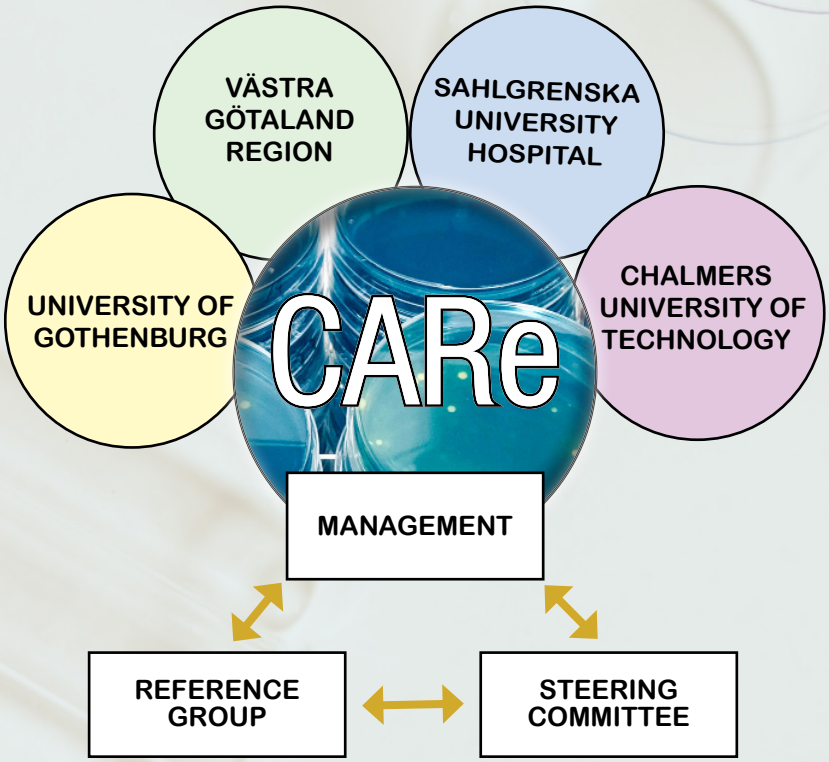
Joakim Larsson and Michaela Wenzel

ABOUT CARe

CARe represents a collaborative venture between the University of Gothenburg, Chalmers University of Technology, the Västra Götaland Region, and the Sahlgrenska University Hospital.

This interdisciplinary initiative bridges healthcare, academia, and regional stakeholders with a joint vision to limit mortality, morbidity and socioeconomic costs related to antibiotic resistance on a global scale through research.

CARe provides a regional network that facilitates cross-disciplinary interactions and collaborations



CHALMERS

Life Sciences
Architecture and Civil Engineering
Chemistry and Chemical Engineering
Mathematical Sciences

UNIVERSITY OF GOTHENBURG

Biomedicine
Biomaterials
Medical Biochemistry and Cell biology
Medicine
Philosophy, Linguistics and Theory of Science
Biological and Environmental Sciences
Chemistry and Molecular Biology
Economics
Education, Communication and Learning
Journalism, Media and Communication
Marine Sciences
Mathematical Sciences
Political Science
Global Studies

CARe has **161** members from **19** departments

RESEARCH

CARe takes a uniquely comprehensive approach to the antibiotic resistance challenge by addressing a wide spectrum of interconnected research areas. CARe adopts a comprehensive approach by incorporating research not only from the natural and medical sciences but also from the humanities and social sciences. By promoting interdisciplinary research such as philosophy and political science, CARe addresses the broader dimensions of antibiotic resistance. What truly distinguishes CARe is our mission to create synergies by bringing together expertise from this diverse range of scientific fields.

Research results are not only communicated by the members through peer-reviewed scientific publications, some of whihc are highlighted on the centre's communication channels, including our website www.gu.se/care. We also engage in numerous other outreach activities as described in this report.

New insights into antibiotic mechanism published

A study, autored and co- authored by CARe members Declan Gray and Michaela Wenzel published in Nature Communications, uncovered a novel mechanism by which antibiotics can effectively target persistent bacterial infections. The study demonstrates that inducing membrane depolarisation in dormant bacterial cells enhances antibiotic efficacy by triggering the production of reactive oxygen species, specifically superoxide radicals, without relying on the traditional Fenton reaction. This discovery provides new insights into the mechanisms underlying the effectiveness of membrane-targeting antibiotics, offering potential pathways to combat persistent infections such as those caused by tuberculosis. The research also highlights CARe's efforts to advancing the understanding of bacterial physiology
Membrane depolarization kills dormant Bacillus subtilis cells by generating a lethal dose of ROS

Declan Gray

Special issue on AMR in leading political science journal

Professor Jon Pierre from CARe contributed as a guest editor to a special issue of the Journal of European Public Policy (JEPP) focused on antimicrobial resistance. Published in October 2024, the special issue explores the intersection of social and medical sciences in addressing the global AMR challenge. It highlights critical areas such as the role of public health experts, citizens' perceptions of AMR, and differences in healthcare systems' responses to AMR. Jon Pierre's work underscores the importance of social science research in shaping policies and strategies to reduce antibiotic consumption and tackle AMR, contributing to this growing field of global public health policy.
Special issue of Journal of European Public Policy on antimicrobial resistance (AMR)

Jon Pierre

New collaboration between Region Västra Götaland and CARe on hospital sewers
A new collaboration between CARe researchers and the Västra Götaland region was launched during 2024. The initiative spawned from a concern from the Region about risks for promoting antibiotic resistance by high concentrations of antibiotic residues in the sewers from hospitals, as previously reported by CARe scientists. During the autumn, Region Västra Götaland has allocated resources to assist with a broad sampling of wastewaters and wastewater biofilms at the six largest regional hospitals and at the corresponding municipal sewage treatment plants. CARe researchers have now taken over and are busy analysing the samples, with support from regional ALF-funding. Professor Christina Åhrén from regional Strama is responsible for compiling uniquely detailed antibiotic use data from all connected wards. The hypothesis is that largely all hospitals sewers can lead to a strong selection for antibiotic resistant bacteria, as previously only shown for the Sahlgrenska hospital (Kraupner et al, 2021). Understanding the extent and exact drivers of this problem is critical for developing targeted solutions. Link to Kraupner et al (2021)

Inger Andersen, Vice General Secretary of the United Nations, General Secretary of UNEP and member of the Global Leaders Group on Antimicrobial Resistance, stressed the needs and possibilities for hospital-specific treatment to remove antibiotics from wastewaters in her opening speech of the UN General Assembly 2024, in conjunction with the adoption of a UN declaration on antimicrobial resistance by the 193 member states (see also section on IMPACT)

CARe researchers among world's most cited in 2024

Three researchers affiliated with CARe - Johan Bengtsson-Palme, Chalmers University of Technology, Joakim Larsson, University of Gothenburg and Erik Kristiansson, Chalmers University of Technology and University of Gothenburg - have been recognized on the prestigious Clarivate Analytics 2024 list of the world's 1% most highly cited researchers. These awards recognize their significant contributions to science and reflects the global impact of their research. It is notable that two out of the three Chalmers researchers on Clarivates list are affiliated to CARe. Link to Clarivate's official list

David Lund at EDAR 7 in Montreal, Canada

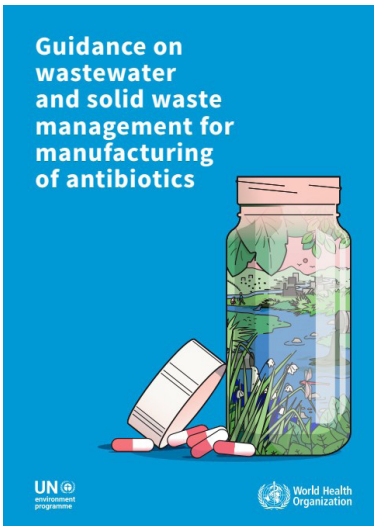
Recognition of young researchers

CARe member David Lund received a prize for his poster at the conference EDAR7 in Montreal. His poster and short-talk described how different genetic and environmental factors influence the horizontal transfer of antibiotic resistance genes. By integrating large amounts of genomic and metagenomic data together with machine learning, David and his colleagues at Chalmers and University of Gothenburg have succeeded in measuring this influence. The analyses show that genetic compatibility between bacteria is the strongest contributing factor for successful gene transfer. They also showed that the coexistence of bacteria in the human microbiome and in wastewater strongly contributes to increased gene transfer. The results promote an increased understanding of how antibiotic resistance genes spread between bacteria and demonstrate new methods to predict the spread of these genes.

IMPACT

WHO guidance on wastewater and waste management from antibiotic manufacturing

In September 2024, the World Health Organization released its first-ever guidance on managing antibiotic pollution from manufacturing, addressing a neglected driver of antibiotic resistance. The guidance was developed over almost two years with contributions from global experts and stakeholders. The guidance outlines human health and environmental targets to mitigate risks associated with pharmaceutical emissions, providing a scientific foundation for regulators, industry, and consumers to implement robust pollution controls. Joakim Larsson from CARe served as lead consultant for the WHO in the development and writing process. WHO guidance



UN Political Declaration on Antibiotic Resistance

In September 2024, the 193 member states of the UN General Assembly adopted a Political Declaration on Antimicrobial Resistance, underscoring the urgent need for a One Health approach to address this global challenge. Two of the 106 adopted statements can clearly be linked to the groundbreaking research by Joakim Larsson and his colleagues at CARe on pollution from antibiotic manufacturing, initiated more than 17 years ago. In preparation for the declaration, Larsson delivered two presentations to the Global Leaders Group during 2024. He also assisted the Swedish Minister for Social Affairs and Public Health Jakob Forssmed and the Swedish delegation in the text negotiations. Including specific commitments on pollution from drug manufacturing marks an important incentive toward scaling up international actions to reduce risks for resistance development driven by pollution from production sites. UN Declaration

76 (recognition): Recognize that pharmaceutical production, including manufacturing operations and waste and effluent generation and management, can impact the evolution and spread of antimicrobial resistance in the environment and further recognize the need for consistency in national regulatory oversight as well as coordinated global action.

91 (commitment): Prioritize the sustainable production of antimicrobials, including through developing and incentivising the adoption of manufacturing standards to reduce the risk of developing antimicrobial resistance and aquatic ecotoxicity in the environment resulting from manufacturing operations.

Clinical recommendations

CARe researcher Susanne Skovbjerg contributed as an expert to the updated 2024 treatment recommendations for pharyngotonsillitis, published by the Swedish Medical Products Agency (Läkemedelsverkets behandlingsrekommendation). Dr Skovbjerg authored the scientific background section, "Biverkningar och ekologiska effekter av antibiotika vid faryngotonsillit", which provides an in-depth analysis of the side effects and ecological impacts of antibiotics in treating this condition. This is an example of CARe contributing to national healthcare guidelines and promoting evidence-based approaches to antibiotic use. Link to guidelines

COMMUNICATION

Nobel Prize laureates in physiology or medicine Charles Rice (2020) and Drew Weissman (2023) and Centre director Joakim Larsson were discussants at the Nobel Week Dialogue in Stockholm, arranged by the Nobel Foundation in conjunction with the award ceremonies during the Nobel Week, December 2024.

The theme of the 2024 Nobel Week Dialogue was *The Future of Health*. CARe's director Joakim Larsson was invited together with four recent Nobel Prize Laureates and additional experts to illuminate the topic from different angles. Among other messages, Larsson emphasized that despite the global interconnectedness of AMR, regional efforts relating to antibiotic stewardship and transmission control tend to pay off greatly also when efforts of other countries are more limited. The show was attended by more than a thousand people on site and was broadcasted on Swedish TV2. It is also available on YouTube. Link to interview

Strama's 25th anniversary. Tinna Åhrén is second from the right

Christina "Tinna" Åhrén participated as a panelist at Strama's 25th anniversary celebration in Stockholm on 15 May, alongside distinguished guests including Crown Princess Victoria and the Swedish Minister for Social Affairs and Public Health, Jakob Forssmed. The event highlighted Sweden's work in limiting antibiotic resistance and Strama's significant contributions over the past 25 years.

- Christian Munthe and Joakim Larsson have also participated in several national roundtable discussions organised by the Swedish Ministry of Health and Social Affairs.

- Carl Fredrik Flach was invited to participate in the Nordic Council of Ministers' expert group on antimicrobial resistance. During the session, he presented insights into the possibilities and limitations of wastewater monitoring for tracking antibiotic resistance.

- In April 2024, CARe conducted a training session for members of the Committee for Medicinal Products for Veterinary Use (CVMP) at the European Medicines Agency (EMA) in Ghent. The training focused on the environmental dimensions of antibiotic resistance, equipping members with knowledge to inform their evaluation and approval processes for veterinary medicines.

- Carl-Fredrik Flach and Joakim Larsson were invited speakers at a webinar organized by UNEP Africa with the aim of strengthening knowledge about antibiotic resistance in the environment.

- Joakim Larsson supported the Public Health Agency of Sweden during the DG SANTE and ECDC review of Sweden's national strategy against antibiotic resistance. This country visit, conducted in September 2024, provided an opportunity to evaluate and strengthen Sweden's efforts in combating antibiotic resistance. Link to strategy

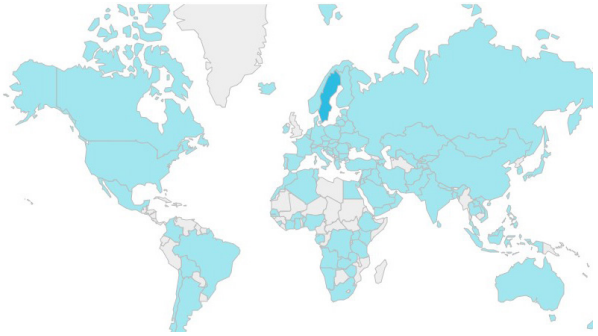
Regeringskansliet
Socialdepartementet

Nordiska ministerrådet

UN environment programme

EUROPEAN MEDICINES AGENCY
SCIENCE MEDICINES HEALTH

CARe's website has had over 5700 visitors from 126 countries during 2024

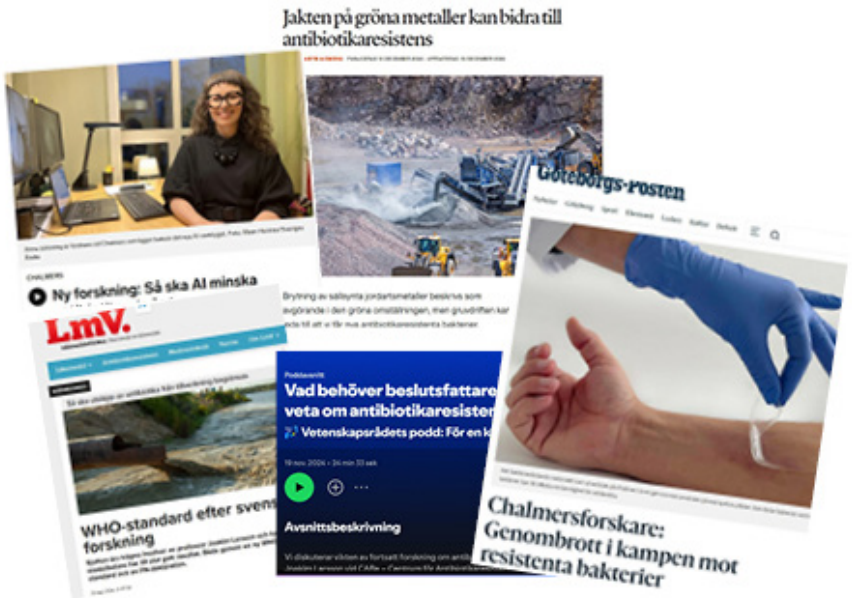


On the website we present a comprehensive overview of the centre's activities, goals, and contributions to the field of antibiotic resistance research.

www.gu.se/en/care

MEDIA

- Johan Bengtsson-Palme was interviewed by Swedish Radio P4 Göteborg about how we can be better prepared for future antibiotic resistance threats Link to interview
- Martin Andersson was interviewed in Göteborgsposten about the development of an antibacterial gel Link to article
- Anna Johnning was interviewed by Swedish Radio P4 Göteborg about how AI can reduce the use of antibiotics in healthcare Link to interview
- Joakim Larsson was interviewed in Läkemedelsvärlden regarding the WHO guidance he contributed to. Link to article
- Roelof Coertze's research was featured in Swedish magazine Extrakt. Link to article
- Joakim Larsson in the Swedish Research Council's podcast: What do decisionmakers need to know about antibiotic resistance?



Joakim Larsson and a well-known desicion-maker, the Swedish Minister for Social Affairs and Public Health, Jakob Forssmed.

SCIENTIFIC MEETINGS ARRANGED BY CARe

CARe ANNUAL MEETING 2024

In June 2024, CARe hosted its annual meeting at Gothia Towers in Gothenburg, bringing together over 90 participants from academia, healthcare and industry for two days.

21 speakers gave talks on these main topics:

- New therapeutics
- Other therapeutic approaches, prevention and diagnostics
- Politics and interventions
- Surveillance and transmission

The keynote speakers included Dermiaid Hughes from Uppsala University, Beatriz Camara from Federico Santa Maria Technical University in Valparaiso, Chile and Camilla Björn from RISE who all gave very appreciated talks.

Alesia Tietze

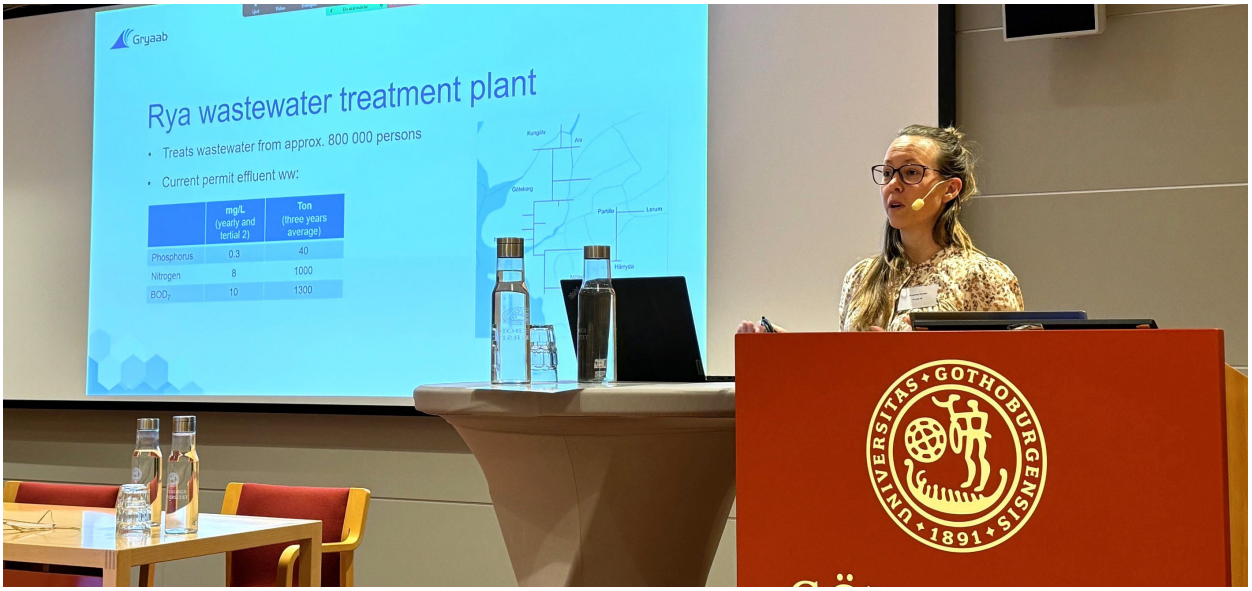
Jon Pierre

Karin Rystedt

CARe WORKSHOPS 2024

Workshop on sewage surveillance

In November 2024, CARe organised the workshop *Sewage Surveillance of Antibiotic Resistance – New EU Requirements: How, When, and, Most Importantly, Why?* to facilitate dialogue and knowledge-sharing on the EU's upcoming wastewater directive. The event gathered over 40 participants from academia, healthcare, and the water and wastewater sectors across Scandinavia. Through presentations and discussions, the workshop underscored the importance of defining the purpose behind sewage surveillance to establish an effective monitoring framework. Insights were shared on the directive's impact, including presentations by Anders Finnson of Svenskt Vatten and Susanne Tumlin from Gryaab, who highlighted that approximately 20 Swedish treatment plants will be affected.



Susanne Tumlin, head of development at Gryaab presenting at CARe's workshop in November 2024. Susanne is also part of CARe's reference group

Webinar on social science perspectives on AMR

In December, CARe hosted a webinar highlighting the social and structural dimensions of antibiotic resistance featuring researchers Jon Pierre, Björn Rönnerstrand, and Daniel Carelli. The event showcased findings on the political and administrative governance of AMR, emphasising the critical role of societal factors in combating this global challenge. Sweden, Denmark, and the Netherlands were identified as leaders in AMR efforts due to their low antibiotic use and robust coordination, while regional disparities within Europe were noted. The webinar concluded with insights from Sweden's AMR Ambassador, Malin Grape, and a discussion on the need for collaboration across sectors, greater political commitment and the integration of social science into AMR strategies.

Symposium on Data-driven environmental monitoring of infectious diseases

In October 2024, CARe researcher Johan Bengtsson Palme co-hosted the DDLS Symposium on Data-Driven Environmental Monitoring of Infectious Diseases, held in Uppsala at SciLifeLab's Navet.

The event brought together local and international experts to explore methods for monitoring infectious diseases, including antibiotic-resistant bacteria, through data-driven approaches. Topics included sewage surveillance, airborne pathogen detection, and environmental and animal disease monitoring, alongside discussions on the technical challenges of implementation.

ORGANIZATION

MANAGEMENT

Professor Joakim Larsson
Centre director, Institute of Biomedicine, University of Gothenburg

Associate professor Michaela Wenzel
Deputy centre director of CARe, Department for Life Sciences, Chalmers University of Technology

Coordinator Lovisa Aijmer
Institute of Biomedicine, University of Gothenburg

STEERING COMMITTEE

Professor Erik Kristiansson
Chair of CARe steering committee, Department of Mathematics, Chalmers University of Technology

Professor Joakim Larsson
Centre director of CARe Institute of Biomedicine, University of Gothenburg

Associate professor Michaela Wenzel
Deputy centre director of CARe, Department for Life Sciences, Chalmers University of Technology

Associate professor Anne Farewell
Department of Chemistry and Molecular Biology, University of Gothenburg

Professor Martin Andersson
Department of Chemistry and Chemical Engineering, Chalmers University of Technology

Assistant professor Alesia Tietze
Department of Chemistry and Molecular Biology, University of Gothenburg

Birgitta Vallhagen
Head of administration, Institute of Biomedicine, University of Gothenburg

Researcher Björn Rönnerstrand
The SOM Institute, University of Gothenburg

Associate professor Carl-Fredrik Flach
Institute of Biomedicine, University of Gothenburg

Professor Christian Munthe
Department of Philosophy and Logics, University of Gothenburg

Professor Christina Åhrén
Strama network, Västra Götaland Region and the University of Gothenburg

Associate professor Elina Lampi
Department of Economics, University of Gothenburg

Professor Fredrik Westerlund
Department of Life Sciences, Chalmers University of Technology

Assistant professor Johan Bengtsson Palme
Department of Life Sciences, Chalmers University of Technology

Associate professor Margarita Trobos
Department of Biomaterials, University of Gothenburg

REFERENCE GROUP

Dr Gunnar Kahlmeter
Former President of European Society of Clinical Microbiology, former director of EUCAST and much more

Dr Camilla Björn
Leader of the focus area Infection Management at RISE and co-leader of Antibiotikasmart Sverige

Dr Leif Dotevall
Deputy Infection Control Physician, Västra Götaland Region

Susanne Tumlin
Head of Development, Gryaab

Dr Martin Johansson
Senior Director, Oticon Medical

CARe members and speakers at the annual meeting in June 2024

EXTERNAL GRANTS

- A SELECTION

Margarita Trobos was awarded 25 million SEK through the Swedish Research Council's Interdisciplinary Research Environment Grants 2024 as co-applicant for the project "UTMOST – Ultra-thin monitoring sensors for implants", a collaborative effort involving Chalmers, the University of Gothenburg, and KTH.

Michaela Wenzel received significant funding for several groundbreaking research initiatives. Toghether with partners from the United Kingdom and Astralia, she secured a JPIAMR grant of 11.6 million SEK for the RAFT project, an international consortium which aims to develop metalloantifungals by integrating inorganic chemistry, machine learning, and antifungal research. The project will synthesise approximately 4,000 new metal complexes to identify promising antifungal compounds, study their mechanisms, and perform preclinical studies—marking the first combinatorial medicinal chemistry-driven initiative in this area.

Additionally, Wenzel was awarded a VR Consolidator Grant of 10 million SEK to investigate how membrane-binding parts of bacterial proteins can permeabilise the outer membrane of tuberculosis bacteria. This project aims to overcome barriers in antibiotic development by identifying peptides that could enable new drug discoveries and reduce antibiotic dosages.

The Wenzel Lab

Fredrik Westerlund was recognised as a 2024 PAR Foundation Grantee for his work using DNA barcoding techniques to study plasmids that spread antibiotic resistance. By tagging DNA in nanochannels, his research aims to identify resistant strains more effectively, advancing diagnostic methods and improving the precision of antibiotic targeting. This work holds the potential to reduce reliance on broad-spectrum antibiotics and facilitate the development of more targeted therapies.

Johan Bengtsson-Palme received over 5 million SEK from the Swedish Research Council's Antibiotic Resistance Call, awarded in late 2024, to support his research on antimicrobial resistance. Additionally, he is a co-applicant in the Nordic Consortium to Monitor and Research AMR, funded by NordForsk, which has provided 800,000 NOK for the period 2025–2026. These projects aim to advance understanding and monitoring of antimicrobial resistance across the Nordic region.

Roelof Coertze

Roelof Coertze has was awarded 6 million SEK by Formas to investigate the potential link between rare-earth metal exposure and the development of antibiotic resistance. Rare-earth metals are essential for green technologies, however, their mining and processing may inadvertently contribute to the spread of antibiotic-resistant bacteria. The project focuses on the phenomenon of "co-selection," where exposure to toxic metals may lead bacteria to develop resistance that also makes them resistant to antibiotics. Collaborating with North-West University in South Africa, this project contributes to the global effort to combat antibiotic resistance while supporting responsible green technology production.

Erik Kristiansson and Anna Johnning have been awarded funding from the Swedish Research Council's Proof of Concept programme for their project "Clinical evaluation of AI-based decision support for treating infections caused by antibiotic-resistant bacteria". This initiative focuses on leveraging artificial intelligence to improve clinical decision-making in the treatment of infections caused by antibiotic-resistant bacteria, aiming to enhance precision and effectiveness in combating these challenging infections.

Joakim Larsson, Carl-Fredrik Flach, Margaritha Trobos and Susanne Skovbjerg all received regional ALF-grants for the period 2025– 2027. Larsson was awarded one of the largest grants in the call (5.25 million SEK) for work on selection of resistant bacteria in hospital sewers. Flach received support for work on sewage surveillance of antibiotic resistance, Trobos' funded project deals with biofilm-associated infections caused by antibiotic-resistant bacteria, whereas Skovbjerg project is on infection caused by pneumococci.

DOCTORAL THESES

- Daniel Carelli, *Bugs and bureaucrats: Institutions, administrative autonomy, and the governance of antibiotic resistance*
- Ann-Britt Schäfer, *Characterization of the in vivo mechanisms of action of cell envelope-targeting antibiotics*
- Margareth Sidarta, *Contribution of Bacillus subtilis cell envelope stress responses to antibiotic survival*
- Charity Sui Gee Ganskow, *Development of antibody-targeted concepts for immunomodulation, biomarker imaging and enzymatic evaluation of bioresponsive pseudoglucosinolates*
- Stefan Malmberg, *Assessment and management of respiratory tract infections in primary care*
- Adam B. Turner, *Biomaterial-induced inhibition of Staphylococcus aureus biofilm formation*
- Paula Milena Giraldo Osorno, *On targeting host-pathogen interaction to prevent biomaterial-associated infections on titanium implants*

CARe contributes to the National Doctoral Programme in Infection and Antibiotics, (NDPIA). Carl Fredrik Flach served as a lecturer and member of the organising committee for NDPIA's course on antibiotics and antibiotic resistance.

EDUCATION

Although CARe has a strong research focus, our members are highly active in teaching about antibiotic resistance at many undergraduate and graduate programmes (not listed here). Some teaching is cross-disciplinary, for example education on ethical aspects connected to antibiotic usage at several courses and programmes at the Sahlgrenska academy and at the School of Business, Economics and Law. This year, CARe continued its commitment to education and capacity building in the field of antibiotic resistance through several impactful initiatives:

Under the guidance of Anne Farewell, over 200 participants completed the online antibiotic resistance course in 2024. This course has now reached thousands of learners worldwide The course covers the scientific basics behind the antibiotic crisis and gives insights into new research and possible solutions. Link to the course The Problem with Antibiotic Resistance

Anna Johnning delivered a guest lecture in the doctoral course ”Artificial Intelligence in Healthcare” at the University of Gothenburg, highlighting AI’s potential in addressing challenges like antibiotic resistance. Additionally she supervised three master’s theses at Chalmers focused on using advanced AI models and metagenomic data to predict and understand antibiotic resistance.

Joakim Larsson provided input for the development of a WHO course on antimicrobial resistance and the environment. The course has already attracted over 7,000 participants globally, further advancing knowledge on the environmental dimensions of AMR.
Link to course

FINANCIAL STATEMENT

The following is a summary of income and expenditures in 2024. Note that this summary only covers administration, communication (internal and external), stakeholder interactions and related activities. The members are responsible for their own research budgets.

Total income 2024 (SEK)	**1 349 604**
- from Sahlgrenska University Hospital	240 000
- from Institute of Biomedicine, University of Gothenburg	348 641
- from Faculty of Science, University of Gothenburg	240 000
- from Chalmers University of Technology	300 000
- from Region Västra Götaland	220 963
Total expenditures 2024 (SEK)	**-1 163 778**
- personnel	-652 800
- running costs	-299 990
- out of which are travel costs	-15 906
- indirect costs (overhead)	-195 082
Result 2024 (SEK)	**185 826**

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