EquityAMR – Digital Equity in Antimicrobial (AMR) policy and practice

Building equity in digital global health: the case of antimicrobial resistance in low and lower-middle-income countries

1. Excellence

1.1 State of the art, knowledge needs and project objectives

EquityAMR seeks to investigate how to **promote health equity** in Low and Lower Middle-Income countries (LLMICs) by bringing together expertise from informatics, global health, microbiology and implementation science to **develop and implement enabling digital technologies** for tackling the global crisis of Antimicrobial Resistance (AMR). The project will generate scientific insights, methodological advancements and operational guidance on how to utilize technology for the public good to help reduce health inequities aggravated by AMR in disadvantaged populations, and produce relevant insights for science, policy and practice about **how digitization can better enable "good health and well-being" (Sustainable Development Goal 3 – SDG3)** The cases of AMR with focus on antibiotic resistance in India and Sri Lanka as examples**.**

The research will focus on building and applying an "equity lens" to understand the world of AMR **policy,** and gaps that occur in **practice** during their implementation. The key vehicle for the analysis is digitization, applied over three domains: i) strengthening surveillance on how to make the AMR problem in underserved populations at required levels of granularity visible to policymakers; ii) integrating diagnostics – test feasibility of low-cost point of care diagnostics, and integrating diagnostic information with AMR surveillance; and, iii) automate prescription practices of antibiotics –to make visible non-responsible prescription practices and integrating with surveillance. Taken together, these initiatives will help build an equity perspective to understand AMR related policy-practice gaps. Drawing on the World Health Organisation (WHO) priorities[1], EquityAMR will focus digital interventions around two policy areas: i) Strengthen knowledge and evidence base through enhanced surveillance; and, ii) Optimising practices of antimicrobial medicines prescriptions in human health. Our research will examine *how sustainable digital interventions can be used to support 1) improved knowledge and evidence base for addressing AMR, 2) optimisation of antibiotic prescriptions.* Within AMR we focus specifically on bacterial resistance, often called antibiotic resistance.

The WHO declared AMR as one of the top global public health threats facing humanity[2], estimated to cost the loss of 10 million lives and $US100 trillion annually by 2050[3]. In 2015, the WHO adopted a global AMR action plan addressing the threat of AMR to the very core of modern medicine, ultimately affecting health security, poverty levels, economic growth, and food security[1 4]. Action to prevent AMR has key societal implications, and failing will adversely affect the achievement of all the UN SDGs[5]. Whilst AMR is a global challenge, it disproportionally affects LLMICs due to high burden of infectious diseases[6], poor infrastructure for timely diagnostics, poverty, and weak governance and health systems. Lack of appropriate regulation, weak diagnostic facilities, absence of relevant prescribing guidelines, non-responsible prescribing practices, unrestricted over the counter sales, availability of substandard antibiotics[7], and lack of knowledge and awareness is fuelling the development and spread of antimicrobial resistance[8]. The annual 5.7 million antibiotic-preventable deaths occur mostly in LLMICs, where deaths from treatable bacterial infections far exceed the 700,000 estimated deaths from infections resistant to treatment[9]. Ensuring access to effective antibiotics is crucial for achieving several SDG3 targets, such as target 3.2. 'End preventable deaths of new-borns and children under 5 years of age' which depend on equitable access to antibiotics to treat pneumonia[10], and target 3.1. 'Reduce the global maternal mortality ratio' depending on effective antibiotic treatment of infections related to pregnancy and birth[11]. **There is an urgent need for LLMICs to take action on both policy and practice levels to balance between equitable access to necessary antibiotics while limiting its harmful effects in humans, animals and the environment domains[12]**.

LLMICs, which tend to have a high AMR burden, for example, India[13 14] also have the weakest surveillance systems, creating a vicious spiral in which health inequities are heightened. Digitization is a key strategy to address the policy-practice gaps in AMR domains[13]. First, it helps strengthen the knowledge and evidence base through surveillance of bacterial resistance and prescribing patterns, generating evidence to build policy and monitor outcomes of interventions. Secondly, digital technologies can strengthen AMR surveillance systems at scale thus enabling visibility of the AMR challenge at the level of populations. Thirdly, digitization can build a holistic picture of infections, diagnosis practices and prescription patterns, to help develop relevant guidelines for antibiotic use and infection prevention and control.

The global proliferation of low-cost digital devices and infrastructures has created novel opportunities to enhance equity and make quality health services more accessible. Expert knowledge and guidance can be implemented to health care providers through e.g. treatment guidelines as well as to underserved and marginalized populations through remote care, facilitated by mobile phones and advanced data analytics. Yet digital technologies also pose risks. Access, ownership, evolution and use of digital technologies is shaped by particular social, political and economic relationships, raising the possibility of digital inequities, further enhancing health inequities[15]. **It is thus a crucial task to build knowledge on the nature and causes of both digital and health inequities, and how digital technologies can be appropriately designed to help address them**.

The WHO global AMR action plan urged "all Member States to have in place, within two years, national action plans on antimicrobial resistance in alignment with the global action plan, and with standards and guidelines established by intergovernmental bodies"[1:12]. Many countries have adopted national action plans but their implementation is challenged by financial and political constraints. This has made it difficult to link policy to concrete improvements in antimicrobial use and health outcomes more generally[16]. AMR involves interwoven dimensions (i.e. social, cultural, economic, and material), **requiring implementation models that account for conditions of uncertainty and interdependencies**, founded on strong research-based evidence[16]**.**

EquityAMR will leverage on state-of-the-art digital health knowledge developed at the Institute of Informatics (IFI), University of Oslo (UiO), under the long-standing HISP (Health Information System Programme) initiative. HISP has developed the free and open-source digital platform DHIS2 (District Health Information System), used for health information systems (HIS) development in 70+ countries, including India and Sri Lanka (dhis2.org), where EquityAMR will be implemented. With partners in India (HISP India – hispindia.org), IFI has developed an AMR surveillance platform for hospitals in India, now being scaled to other contexts (eg in Ethiopia, Kenya and Ghana) with German partners and with guidance from the Norwegian Institute of Public Health and WHO, Geneva. EquityAMR will extend this AMR platform to develop, implement and evaluate digital interventions in domains of surveillance, diagnostics and prescriptions, crucial for bridging policy-practice gaps.

Primary objective: *To understand policy-practice gaps in AMR surveillance, diagnostics, and antibiotic prescribing to build knowledge on how digital interventions can help address these gaps.*

Secondary Objectives: ***i)*** *To understand the AMR policy environment and how these shape practices of surveillance of resistance, diagnostics, and antibiotic prescriptions;* ***ii)*** *Build knowledge on normative design frameworks for digital systems that can enhance equity;* ***iii)*** *Build contextualized and scalable implementation models for digital interventions for supporting AMR policy and practice;* ***iv)*** *Understand how digitization can contribute to responsible and optimized antibiotic prescribing practices;* ***v)*** *Test feasibility of how modern Point of Care diagnostic methods can strengthen surveillance systems; and, vi) develop analytical methods relevant for large AMR datasets.*

1.2 Research questions and hypotheses, theoretical approach and methodology

EquityAMR's theory of change (figure 1) consists of 3 key components: i) understanding existing socio-technical conditions shaping AMR policy and practice and ensuing gaps; ii) designing and implementing digital interventions to help address identified gaps; and, iii) assessing outputs in terms of improved digital AMR equity, concerning surveillance, and responsible[17] use of antibiotics.

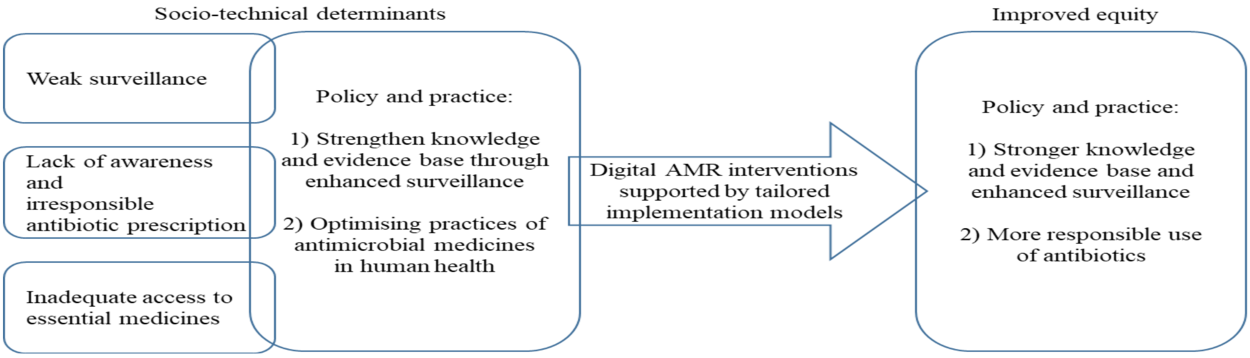

Figure 1: EquityAMR theory of change

This theory of change helps to formulate 3 key hypotheses (H) to guide the research:

H1: **AMR policy to practice gaps are shaped by complex socio-technical determinants that must be understood and incorporated into tailored digital implementation frameworks**

Current research recognizes AMR as an evolutionary challenge accelerated by a compound of social, cultural, material and economic factors[18]. Design and deployment of interventions to strengthen surveillance and prescription of antibiotics must draw on knowledge about socio-technical contextual determinants[19], existing theory and evidence[20 21], and implementation and evaluation frameworks[16 22]. We will develop complexity science-inspired implementation models that go beyond traditional evidence-based medicine paradigms, and focus on building multiple contested truths of a phenomenon rather than linear cause-effect understandings [19 22]. The hypothesis translates into the following research questions: **RQ 1a**) How, and by which socio-material circumstances are global AMR policies translated into national and local policy and practice, and how can digital interventions bridge policy to practice gaps? **RQ 1b)**: What are appropriate implementation models to support tailored digital interventions to bridge policy to practice gaps and apply them at scale?

H2: **Strengthened *AMR surveillance systems* can help make visible granular level underserved populations, to enable stronger linkage between policy and practice.**

An equity perspective acknowledges that AMR is not the same for everyone; men and women, and different groups in society (such as rich and poor and urban and rural), might be at different risk of getting impacted by AMR, requiring different approaches for mitigating risk. This acknowledgement leads to more deliberate design and implementation of AMR interventions that look beyond the aggregate to examine AMR patterns, pathways and key drivers in terms of relevant social stratifiers such as gender, occupation, income, age, geography and education levels. Strengthening surveillance systems can enable collection of granular data and make visible conditions of inequity and support both policy and practice. The following research question will be addressed: **RQ2)** How can appropriately designed digital interventions strengthen surveillance and make it more holistic by incorporating conditions of prescriptions and diagnosis to enhance equity?

H3: Digital interventions designed to build more responsible and evidence-based practices of *prescribing antibiotics* will strengthen more equitable access to antibiotics

In many high-income countries, AMR has shown to be reduced with programmes to reduce health care associated infections and by optimising prescription practices[21 23]. LLMICs tend to not have robust monitoring systems of antimicrobial prescriptions, which is essential for tracking national and global trends, create baselines to correlate antibiotic use and resistance over time. Effective surveillance systems can also contribute to making the informal and non-responsible practices of antibiotic prescription practices more visible, and consequently possible to be reduced through policy measures. EquityAMR assumes that strengthening surveillance of prescription practices can enhance evidence-based practices and policies, aimed at enhancing equity. **RQ3**) How can appropriately designed digital interventions strengthen more responsible antibiotic prescribing practices? **RQ4**) How can we build analytical models for large data sets of AMR surveillance and prescription data.

Methodology
EquityAMR will be designed and implemented by a team of high-quality institutions in the North and South based on long-standing equitable partnerships, depicted in the following schematic:

Institutions North	Expertise	Institutions South	Expertise
Institute of Informatics (IFI), Norway, H	Health informatics	Birla Institute of Technology and Science (BITS), India	AMR diagnostics
Center for Sustainable Health Education (SHE), Norway	Implementation science, global health, AMR policy	Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCITMST), India	Digital Health, Community medicine
		RDGMC, Ujjain, India	Domain experts on AMR testing and surveillance
Karolinska Institutet (KI), Sweeden	Global health, AMR policy and research interventions	HISP Sri Lanka, HISP India and Doctors for You, India	Digital Health, project implementation

EquityAMR will be implemented over three interconnected phases: i) analysis of AMR policy and practices relating to surveillance, prescribing and diagnosis, and the ensuing gaps; ii) design appropriate digital interventions to address identified policy-practice gaps; and, iii) assess and improve the effectiveness of these interventions. While each Work Package (WP) will be the primary responsibility of 1/2 partners, data and findings will be shared across WPs, to enhance interdisciplinarity.

India and Sri Lanka, two lower-middle-income countries, are empirical settings for EquityAMR, and are long-term partners in IFI's HISP initiative, with interest in extending to AMR. Both countries experience challenges of unauthorized antibiotics prescription, over the counter sales, lack guidelines of antibiotic use, deficient diagnostic facilities and weak surveillance systems. Existing applications set up on the WHONET platform[24] is challenged by weak infrastructure and trained human resources, which constrain reporting to WHO's Global Antimicrobial Resistance System (GLASS)[25]. The countries offer interesting similarities and contrasts, which will enable rich insights into the issue of equity. We summarize some key comparative indicators:

Indicator	India	Sri Lanka
Population (in thousands) total 2016	1324171	20798
Human Development Index Rank (2014)	130	73
Poverty Headcount Ratio at $1.25 a day (PPP) % of population (2010)	32.7	4.1
Total Expenditure on Healthcare as a % of GDP (2014)	4.69	3.5
Private expenditure on health as % of total expenditure on health (2014)	69.96	43.94
General government expenditure on health as a percentage of total government expenditure (2014)	5.05	11.17
Physicians density per 1000 population (2015)	0.758	0.881
Neonatal Mortality Rate(per 1000 live births, 2019)	21.7	4.3
Maternal mortality ratio (per 100 000 live births, 2017)	145	36

Table 1: Comparative health indicators from India and Sri Lanka
(Source: WHO key country Indicators, country summaries: https://apps.who.int/gho/data/node.cco.keyind?lang=en)

EquityAMR will examine how varying contextual conditions within and across countries shape AMR policy-practice gaps in surveillance and approaches to introduce digital interventions in these sites:

Location and partners	Setting specifics
Kerala state, India (2 districts) Partner: Sri Chitra Tirurnal Institute of Medical Sciences and Technology (SCIMST)	1. Has the best disease surveillance systems in the country; 2. Strong health system, with indicators comparable with global best practices: 3. High level of computerization in primary and tertiary care facilities with focus on patient-level care; 5. SCIMST is designated Centre of excellence in India; 6. UiO has strong links with SCIMST since 2005.

Himachal Pradesh state, India (3 Medical Colleges) Partner: HISP India, technical partner for State	1. All districts hospitals have computerized hospital information systems since 2010; 2. Ongoing successful pilot on AMR surveillance ongoing in one medical college for 2 years: 3. State interested in scaling the system to other 2 medical colleges; 4. HISP India (UiO partner) has strong presence in state, with good trust of the state government, 5. HP is a progressive state, with strong public health systems.
Madhya Pradesh state (2 districts), India R.D. Gardi Medical College (RDGMC)	1.No computerized AMR system, providing for contrast with other sites; 2.Private not-for-profit organization including two hospitals and primary care units and demographic surveillance site; 3. Ongoing research in antibiotic use and resistance since 2004, within the framework of State Action Plan on AMR, with established strong links to Karolinska Institute.
Bihar state, India (11 Medical Colleges in the state) Doctors for You	1.No computerized AMR system; 2. Is a state with one of the highest antibiotic consumptions in the country; 3. Ongoing collaboration with HISP India on AMR surveillance project in Bihar; 4. HISP India also has extensive experience of working on health information systems in Bihar
Western Province, Sri Lanka Partner: National Hospital of Sri Lanka (NHSL), associated with the University of Colombo; HISP Sri Lanka, implementation partner	1. Has most numbers of healthcare institutions in the country (35 tertiary, and 200+ primary care institutions); 2. NHSL, is affiliated with the Colombo medical faculty and a designated centre of excellence, with moderate levels of digitalization; 3. The microbiology department of the NHSL has been successfully contributing to the AMR surveillance of the Ministry of Health.
Central Province, Sri Lanka. Teaching Hospital, Peradeniya (THP) and District General Hospital (DGH), Nuwaraeliya, HISP Sri Lanka, implementation partner	1. 2nd largest healthcare setting in the country with 27 tertiary and 150+ primary care institutions. 2. The partner, THP, is affiliated with Peradeniya medical faculty with moderate levels of digitalization; 3.Microbiology department, THP, has successfully contributed to AMR surveillance of the Ministry of Health. DGH is a leading tertiary care hospital in the province.

Building on principles of implementation research the project is set up as an explicit process that considers the determinants of the problem, relevant theory and available empirical evidence of interventions with proven efficacy and potential to substantially reduce AMR disease burden[16], thereby promoting equity. Qualitative and quantitative data material will enable rigorous planning, implementation and evaluation achieved through the following 4 inter-connected WPs.

WP1. Understanding AMR policy to practice gaps; Leader: SHE: Eivind Engebretsen (co-lead – year 1); Ida Lillehagen (co-lead year 2-4); Trisha Greenhalgh; Partners: IFI; BITS; HISP India, Doctors for You

***RQ1 a)**:* How, and by which socio-material circumstances are global AMR policies translated into national and local policy and practice, and how can digital interventions bridge policy to practice gaps?

***RQ1 b)**:* What are appropriate implementation models to support tailored digital interventions to bridge policy to practice gaps?

Research methods and data: i) discourse analysis of relevant policy documents; ii) observation, interviews and focus group discussions with policymakers, health care providers, and patients to understand practices, and also policy-practice gaps.

Task 1: Identify and analyse national, regional and local AMR policy documents related to surveillance and antimicrobial use: Relevant policy documents (eg national and state action plans[26] [27] [28] [29] [30] programmes and local directives) will be analysed drawing on Bacchi's approach 'what's the problem represented to be?'[31] to identify various definitions of problems and solutions to the AMR challenge[32], probe underlying assumptions in policy framing with a specific sensitivity for inequity.

Task 2: Understand appropriate implementation models for digital interventions. Follow processes of digital interventions and their implementation to link socio-technical circumstances of the empirical sites in India and Sri Lanka, to discern policy-practice gaps. Greenhalgh's well-cited NASSS (non-adoption, abandonment, scale-up, spread, sustainability) framework[22], will guide development of complexity science-inspired implementation models and principles for their scaling.

Task 3: **Build strong feedback loops between understanding of implementation dynamics and support for digital interventions.** We will use a variety of modes of communication, both among project members and with users, to ensure that local needs and concerns remain central in implementation, and the digital interventions are continuously tailored for context.

Deliverables: i) Analysis of relevant policies, programmes and interventions across two policy domains; ii) Contextualized understanding of policy-practice gaps driving inequity and the potential role of digital interventions; iii) Digital implementation models inspired by complexity science.

WP2. Delivering digital interventions for AMR as public goods, Leader: Sundeep Sahay, IFI, Partners: SCTIMST; Kerala; HISP Sri Lanka; RDGMC, Ujjain HISP India; and Doctors for You.

RQ2: How can normative design frameworks based on public goods help build appropriate digital interventions to enhance equity in AMR management?

This WP focuses on challenges around designing digital technologies to enable equitable access to AMR (concerning surveillance, prescriptions, diagnostics), within normative public goods-based design frameworks[33], to maximize geographical scaling, relevant for addressing AMR challenges[34].

Research methods and data: i) building participatory design requirements through work-study analysis of existing practices and information flows and qualitative user interviews; iii) prototyping methods of system development based on incremental improvements to strengthen surveillance, automate prescription practices, and integrate surveillance with diagnostic point of care systems

Task 1: Work with WP1 and WP3 to understand and document design requirements to strengthen holistic AMR surveillance system and create the system development blueprint.

Task 2: IFI with its Indian partner (HISP India) has built a platform on DHIS2 for AMR surveillance, which will be extended to translate the system blueprint (task 2) into usable digital products.

Task 3: Using established prototyping methods, the AMR platform will be enhanced with cycles of incremental releases, user feedback, upgrading of the platform and new releases.

Deliverables: i) An AMR tool with surveillance facilities, digitizing prescription practices and integration with point of care diagnostics; ii) guidance and training resource material.

WP 3. Building more responsible antibiotic prescribing practices; Leader: Cecilia Stålsby Lundborg, Karolinska Institutet, Sweden, Partners: RDGMC, SCTIMST, HISP Sri Lanka, HISP India

RQ3*:* How can digital interventions strengthen more responsible antibiotic prescribing practices

Research methods and data: i) Qualitative: interviews and focus group discussions; ii) Quantitative data: prescription patterns over time, through existing computerized systems and continuous data collection; iii) Big data analysis of historical usage of antibiotics, to analyze patterns of prescriptions and how they relate to prescription guidelines from global and national levels.

Task 1: **Explore the requirements and feasibility of digitization of prescription practices.** Practices related to building and implementing prescribing guidelines and infection control practices will be studied based on qqualitative data analysed using manifest and latent content analysis[35] or thematic analysis[36]. In sites more advanced in digitization (such As Kerala) We will focus on understanding how digital data is used in practice and policymaking, such as in identifying risk factors[37 38] or bacterial infections for developing local prescribing guidelines[39 40]. Where digitization is in its infancy (such as in Bihar) readiness to adopt digital systems as well as facilitators and barriers for their implementation will be in focus.

Task 2: **Evaluation of new point of care diagnostic system for identification of bacteria and susceptibility testing at primary health care level.** Where digital systems are available, integration of data from the point of care diagnostics system with surveillance will be explored. In a setting without digital resources, this new system will be implemented and its influence on prescribing practices will be followed. Data will be integrated from diagnostic systems with surveillance, to expand analysis of prescribing practices.

Deliverables: i) Status of antibiotics policy and practice environment; ii) Feasibility analysis for digital platform for AMR surveillance and prescription management; iii) Build understanding of how point of care diagnostic system for bacterial identification can be integrated with the surveillance system.

WP 4. Build an excellent international research environment in Norway for interdisciplinary AMR research, Leader: All WP leaders

RQ4 a) How can systematic evaluation of interventions lead to new concepts and practices?

RQ4b) How to build theoretical, methodological and operational guidance on AMR policy and practice and make them transferable to other LLMCs and beyond?

Research methods and data: i) use of realist and complexity evaluation methods[41 42] to understand what digital interventions works, for whom, in which circumstances, why and how, and understand the nature of unexpected consequences. Data collection will use questionnaires, interviews and workshops, and dissemination will occur at two levels: project-level in empirical sites; at meta-level, to link with other AMR research networks (such as in NIPH).
Task 1: Further develop realist and complexity evaluation frameworks of AMR interventions.
Task 2: Conduct a comparative analysis of findings across sites to build theoretical perspectives on the challenge of AMR inequity in LLMICs and how digital interventions can address them.
Task 3: Engage with other relevant university departments and research networks to contribute to strengthening a world-class research environment on AMR in Norway.

Risk management strategy

Potential risks	**Risk mitigation strategies**
One of the states in India pulls out of the project because of political changes or for other reasons	Design includes multiple states to ensure empirical rigor, even if one state drops out.
Travel restrictions arising out of the Covid-19 pandemic	Will plan to do online interviews and rely heavily on local team members
Technical complexities in building digital interventions	Will draw upon the core DHIS2 development team at Oslo for advice and support
Funding support gets limited	Supplementary HISP Research funds can be sought if needed

1.3 Novelty and ambition

Scientific: The interdisciplinary approach combining informatics, global public health, microbiology and social sciences is a novelty capable of building rich insights into a complex global problem. The equity perspective helps examine AMR not only as a medical problem but a social and cultural challenge shaped by what people do in everyday social and work lives. Another novel ambition is to We will strengthen research on how to implement context-sensitive digital interventions, and evidence base for research and policy.
Empirical: EquityAMR will extend studies of AMR policy implementation by analyzing the complex interrelationship between technology, policy and practice within situated contexts in multiple sites in LLMICs, thereby informing further interdisciplinary empirical inquiry.
Methodological: Combining multiple methods, the project will develop new methodologies for mapping and improving global to local policy implementation with a focus on building equity.
Operational: We build upon two decades of HISP experience and extend it to the relatively unexplored domain of AMR. A novelty is in the adoption of an equity-based approach which emphasizes principles of health systems strengthening and socio-technical models. This takes AMR research beyond the clinical and patient-centric domain to a population-based one thereby enhancing the scope of impact.

2. Impacts

Scientific impacts: **i)** establish a world-class research environment in Norway in the multi-disciplinary and novel and important domain of AMR; **ii)** high-quality academic publications in interdisciplinary peer-reviewed international conferences and journals spanning informatics, global health, implementation science, infectious diseases and ICT for Development; **iii)** generation of case studies relevant for IFI's Masters programme in Digital Health; **iv)** expand SHE's proposed PhD research school in Global Health; **v)** supporting researchers from LLMICs to contribute to building tertiary research and education capacity in informatics, ICT4D and Global Health; and, **vi)** expand research networks for applying for EU Horizon and RCN calls.

Societal impacts: **i)** build policy briefs oriented to achieve AMR equity, contributing to the achievement of SDGs where equity is a cross-cutting aim (SDG1 to end poverty; SDG3 to ensure health) and where equity is an end goal in itself (SDG 5 and 10); **ii)** enhance societal awareness on AMR by publishing in newspapers and trade journals; **iii)** support hospitals to develop clinical guidelines on more responsible use of antibiotics; and, **iv)** Enable universal access to free and open-source AMR surveillance platform, which provides economic opportunities for local entrepreneurs to build digital innovations.

Pathways to scaling of impacts: **i)** leveraging on IFI's HISP network to help support strengthening AMR surveillance processes in partner countries; **ii)** IFI as a collaborating partner for WHO will make available project outputs to WHO for enabling further dissemination to member states,

2.1. Measures for communication and exploitation

EquityAMR will have dedicated resources for professional communication and exploitation of results: **i)** AMR platform and learning resources will be released as open-source digital goods, made available to the 70+ HISP partner countries; **ii)** All publications will be disseminated in open-access media; **iii)** Maintain project website and blog and use Teams for project management; **iv)** Case studies and course modules developed to be incorporated into courses being taught at the partnering institutions and planned under IFI's Masters in Digital Health starting fall 2022; **v)** 10. Policy briefs will be developed to support government policymakers to help to strengthen equity; **vi)** Research workshops (one in each country every year) to enable active engagement of local researchers; **vii)** The project will connect with global and national AMR related networks, including: WHO Collaborating Centre Global Strategy Lab; NORSE in Norway; Combat-AMR network in Germany; Antibiotic Resistance India (IIMAR; Antimicrobials in Society (AMIS); Interdisciplinary Forum for Research on AMR (INFRA).

3. Implementation

3.1 Project manager and project group

The interdisciplinary research team will include disciplines of informatics, infectious diseases, global health, biological and social sciences: **Institute of Informatics (IFI), University of Oslo:** IFI's **Prof. Sundeep Sahay** will be PI, who has extensive experience in research, policy and practice of HIS in LLMICs, including in India and Sri Lanka. He is a pioneer of IFI's flagship R&D HISP initiative which has produced DHIS2, now a global standard for HIS development (see dhis2.org). Sahay is a well-published researcher in ICT4D and Digital Health and has conducted policy assignments for various global health organizations, including in India and Sri Lanka. **Arunima Mukherjee** drawing upon her experience as Technology Lead for a multi-country EU project will serve as Research Coordinator. Adjunct Professor **Ernst Kristian Rødland**, an infectious disease AMR specialist, will strengthen the medical expertise. **Centre for Sustainable Healthcare Education, University of Oslo, (SHE)**: WP1 will be co-led by **Prof. Eivind Engebretsen** and **Dr Ida Lillehagen. Prof. Eivind Engebretsen** is a distinguished scholar doing ground-breaking research on knowledge translation and sustainability in global health through social sciences and humanities perspectives with key focus on AMR. **Dr Ida Lillehagen** brings expertise in ethnographic methodology and discourse analysis, applied to global health. SHE also includes **Prof. Trisha Greenhalgh**, a globally renowned scholar on evidence-based medicine, implementation science and the study pf health informatics projects from a critical social sciences perspective. **Karolinska Institutet (KI), Sweden:** WP3 will be led by **Prof. Cecilia Stålsby Lundborg**, Department of Global Public Health (KI), with more than 20 years research experience on antibiotics from surveillance to policy, with a LLMICs especially focus on India. She has published extensively in collaboration with Indian researchers on antibiotic surveillance, hygiene antibiotics in the environment and use. She will lead WP3, particularly related to studying antibiotics prescription practices and how these can be integrated with the digital surveillance systems. RDGMC, Ujjain, an academic partner will be led by Professor **Manju R Purohit**, Microbiology and Assoc Prof **Megha Sharma**, Pharmacology, will lead the research and empirical work relating to implementation of digital surveillance interventions in their teaching hospital, and in guiding the analysis of historically collected AMR data by them. **Birla Institute of Technology and Science (BITS), Pilani**, **Prof. Suman Kapur** in the Department of Biological Sciences is an eminent researcher at BITS, a premiered higher education institute. She has expertise in research in genetic markers for communicable and NCDs and has developed point of care diagnostic technologies for AMR (called RightBiotic) to be tested in this project. The project will test out and study the techno-cultural feasibility of using the technology in community based setting and for integrating testing data with the AMR surveillance systems. **Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST), Trivandrum, India,** is an institute of national importance in India under the Ministry of Science and Technology, and **Prof. Biju Soman** will guide data science work in the project. He has attracted significant research funding from national and international agencies and works closely with state government projects. He heads the regional technical resource centre (RTRC) for Health Technology Assessment India of the

Department of Health Research (DHR), Govt. of India. Kerala state is a best practice in India on AMR related action, and Dr Soman will lead the study of these best practices and how it can be shared with project partners in other states

HISP Sri Lanka (R&D Partner): Will be led by **Dr Suranga Dolamulla,** the Director, Tertiary Care Services of the MoH, Sri Lanka, has 20 years of work experience as a health administrator, policymaker and researcher will work with and a practicing clinician. As Regional Director, he has managed various public health programmes funded by global partners. He is a Clinical Academic Fellow at the York Teaching Hospital NHS, UK, on AMR stewardship. Dr. Dolamulla will be technically supported by Dr. Roshan Hewapathirana, an IFI PhD graduate, who will collaborate with HISP India with the DHIS2 based surveillance system development, its customization to the Sri Lankan country context, and also provide local implementation support in 3 hospital intervention sites in the country. **HISP India (R&D partner):** Is IFI's technical partner in South Asia to support the DHIS2 technical development work. Gitika Arora, lead on the project, will head the technical work in the design and development of the DHIS2 based AMR surveillance platform, and will be responsible to technically support (through 5 staff hired for the project) the other project partners in adapting this platform to their individual settings and provide them with ongoing implementation and capacity building support. **Doctors for You (DFY – R&D partner**), headed by **Dr Ravikant**, is a government partner for disaster management, and will coordinate with the Bihar state government to implement the digital surveillance interventions in 10 medical colleges of the state. EquityAMR will recruit Research officers and Research Assistants (3 in India + 1 in Sri Lanka) and 3 Research Officers (for data management) to support the empirical work in partnership with the different country institutions. Additionally, EquityAMR will hire 1 postdoc based in Norway and 1 researcher with PhD qualification who will be based in India. 1 Researcher and 1 Research Assistant will be hired through SHE.

3.2 Project organisation and management

The project is organized through 4 WPs addressing specific research questions, as detailed earlier, and there is an additional WP (led by IFI) for project coordination and management. The project timelines are depicted through the Gantt chart below. Teams based project management tool will be used to coordinate across all activities, like meetings, planning and others.

Gantt chart

WPs & tasks	**2021**	**2022**				**2023**				**2024**				**2025**		
WP1.Understand policy practice gaps	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Planning, recruitment, ethical approvals																
Task 1																
Task 2																
Task 3																
Deliverables																
WP2.Delivering digital interventions																
Task 1																
Task 2																
Task 3																
Deliverables																
WP3.Improve antibiotic prescription																
Task 1																
Task 2																
Deliverables																
WP4. Build an excellent research group																
Task 1																
Task 2																
Task 3																

Deliverables																

Ethical and gender perspectives: The project will be implemented by an interdisciplinary team derived from equitable partnerships (in terms of WP leadership, and hiring) between institutions in the North and South. The project is underpinned with deep ethical concerns for building equity around AMR, and the implications of ICTs on society, Sahay is knowledgeable in these issues, given his background in the Philosophy and Sociology of ICTs, and teaching a Masters course on "ICT for development: Are we making a better world?" The project will not have direct access to any patient identifiable data and will observe all necessary global and national ethical and data protection issues as well as abiding by national and international guiding principles through appropriate individual and institutional consent and NDAs. The checklist issued by the national committees for research ethics will be used when preparing the various study protocols. We will adhere to the European General Data Protection Regulations for data security, data safety, data storage and data transfer. 50% of the WP leaders are women and gender parity will be maintained for all recruitment of project staff.

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