Routinizing practices and stabilizing institutional work: A case of digital monitoring of Antibiotic Resistance (ABR) in India

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Abstract:

Antibiotic resistance (ABR) presents a widespread, complex threat to global health and achieving universal health coverage. A key global and national priority to address this challenge is by creating a digitally enabled evidence base to make visible this problem and strengthen policy and practice interventions. The invisibility of the ABR problem is particularly acute in low and middle-income settings, where digitization in this domain is in its infancy, and there is a high prevalence of infections and severe constraints of capacity and infrastructure. How can a digital ABR reporting system be introduced, routinized, and stabilized in such a context that the ABR challenge can be better managed, is the focus of this paper. The paper combines IS concepts from requirement analysis and implementation research together with concepts from institutional theory, to develop an analytical framework that makes the following contributions: i) how can new practices relating to a digital intervention be routinized into everyday work; ii) how can these routinized practices be translated into stabilized institutional work to ensure their sustainability over time; and iii) what is the work required to bridge the gaps between the formal institutions that accompany the new digital system and the informal constraints that are experienced in implementing them.

Keywords: Digital ABR Monitoring, Practices, Institutional Work, India, Routines, Translations.

[Department statements, if appropriate, will be added by the editors. Teaching cases and panel reports will have a statement, which is also added by the editors.]

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1   Introduction

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi, and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread (WHO, 2018). Antibiotic resistance (ABR) is a subset of antimicrobial resistance and is described by the World Health Organization (WHO) as 'a global crisis' and the perfect example of the complex, multi-sectoral, multi-stakeholder challenges increasingly facing the world (WHO, 2018). ABR is endangering the future of societies (O'Neill, 2016), including the achievement of all Sustainable Development Goals (SDGs) *(*Cars & Jasovsky, 2015*)*. ABR impacts the world inequitably (WHO, 2021), with Low- and Middle-Income Countries (LMICs) amongst the worst hit, due to the high prevalence of infectious diseases, overcrowding, poor sanitation, and weak access to diagnostics, inadequate monitoring, indiscriminate antibiotic use, and weak regulations. India is the world's ABR capital (Chaudhry & Tomar, 2017) reporting an annual ABR attributed mortality of 700,000, estimated to reach 10 million by 2050 globally (O'Neill, 2016). India is the biggest producer (Srividhya, 2021) and consumer of antibiotics globally, reflected in the more than 100% increase in antibiotic use between 2000 to 2015 (Klein et al., 2018). Compounding this problem is the relative lack of effective monitoring and reporting systems, and while 163 countries have developed National Action Plans (NAPs) to combat ABR, very few have materialized them effectively into everyday institutionalized practices. A mere 2.3% of monitoring systems globally are in LMICs (Klein et al., 2019) contributing to the vicious cycle of poor visibility about the ABR problem which limits focused interventions that magnify its spread and associated social inequities. Breaking this vicious cycle of poor visibility of the ABR problem represents a key challenge for information systems research and practice.

The informational priority has been highlighted by the NAPs as a strategic aim to **strengthen the knowledge and evidence base through surveillance**. This is easier said than done because it involves systematic information on various complex and inter-connected parameters, such as i) antimicrobial susceptibility testing (AST); ii) monitoring of resistance; iii) monitoring the consumption and use of antibiotics; and iv) specific skills on areas such as medicines management, hospital-acquired infections, and infection prevention and control. All of these represent new forms of knowledge and require specific skills, capacities, and infrastructure, extremely limited in the public sector of most LMICs. This paper argues that trying to build these new forms of knowledge and skills, to enable digital ABR monitoring, will need an understanding of the interaction between the digital information system and organization both at micro and macro levels. At the micro-level, new knowledge concerns what and how new or redefined information practices get created and institutionalized, and at the macro level of the hospital facility, how these new institutions are created that can allow for systematic and continued monitoring of ABR. These institutions, for example, are related to the development of antibiotics guidelines which can guide the institutional work of physicians providing clinical care and of policymakers to monitor trends in the prevalence of ABR to help develop interventions around resource allocations in areas hardest hit by the problem.

This paper seeks to address the following twin challenges: i) what are the novel institutional practices that need to be introduced and routinized to support a new digital ABR reporting system, and ii) how can these routinized practices be translated into everyday institutional work to ensure their sustainability. To address these twin challenges, the paper develops a more granular view of information practices and examines them under three interconnected phases of the ABR information system development process: i) in building system requirements; ii) during implementation while making the system work in the field setting, and iii) during the process of integration of the system into institutional work processes. While acknowledging these phases are in reality interconnected and overlapping (Sein et al., 2011), for analytical purposes we have made this distinction.

Our conceptual approach thus spans two interconnected levels of everyday practices and their integration with institutional work, drawing upon two broad strands of research. One relates to IS research on systems requirements and implementation, which helps to understand the micro process dynamics from an IS perspective. Two, and which arguably presents a novel dimension of our theoretical approach, is that we situate this IS perspective within a stronger institutional context, by selectively drawing upon concepts from institutional theory. Further, we adopt as an epistemological device a practice-based lens across interconnected dimensions of the micro of the everyday work informing systems requirements and implementation, with the macro that concerns the routinization of work into institutional work. Such a conceptual framing provides for a rich and holistic analytical lens to interrogate the following research question:

How are everyday information practices around the processes of requirements and implementation of a digital ABR reporting system routinized and translated into institutional work?

The empirical base for the analysis of this research question is a public hospital in India with a high patient load (of around 2000 patients every day) that while struggling with historically existing constraints of manpower, resources, and digital infrastructure, has taken the (arguably brave) decision to implement a digital ABR reporting system. The processes of requirements, implementation, and routinization must necessarily be situated within existing practices, workflows, and constraints. The practice-based epistemological lens helps to analyze the routines that currently exist and how these need to be systematically expanded and redefined to incorporate the new institutional requirements that the ABR reporting system demands. This paper describes the process and challenges of implementation and use of an ABR monitoring system first through a case study and second through an illustration of the case study from an institutional theory lens. We bring together concepts from IS research and institutional theory to formulate an analytical framework. This framework helps to understand the contextualized routinization of the use of technology while considering the institutional setting.

The rest of the paper is organized as follows. In the next section, we describe the research methods followed by the case study in section 3. Section 4 presents the case analysis guided by relevant literature and a resulting conceptual framework. Discussions and conclusions are presented in section 5.

2   Research Methods

This is an ongoing longitudinal study started in 2019 in a north Indian state (referred to as the State), with two key objectives: i) to understand practices around antibiotics consumption and prescriptions through two means. One, by understanding the antibiotic consumption behavior of citizens through means of semi-structured interviews. Two, studying the information practices around the testing of resistance, and how these shape antibiotic prescribing practices of physicians. Taken together, these two means of empirical engagement contributed to defining a rich picture (Checkland, 2000) of the problem which we try to address through the design and implementation of a digital ABR monitoring application through a practice-based approach, of how they are routinized and institutionalized over time. This study was part of a larger initiative under the long-standing ongoing efforts of a national NGO called HISP India working on strengthening digital public health systems, of which all the three authors of the paper are a part of, including in the State.

2.1   Role of the Researchers

The first author of this paper is both a researcher and a part of the HISP team. As a researcher, she is studying the practices of antibiotics use and the process by which digital systems can usefully intervene. At HISP India, she is involved in the practical processes of system design, development, and implementation of the digital ABR monitoring system. These two roles provide her with both the proximity of observing practices in context and the distance to reflect on these processes from a research lens. The second and third authors are information system researchers have supported the conceptual development and study contributions.

2.2   Research Site

This study is based in a tertiary hospital setting in a state located in northern India. The state has microbiology testing facilities only in four tertiary hospitals, of which we focused on one located in the foothills. The State has a hilly geographic terrain that makes access to health care services a challenge for its about 7 million citizens (General, 2011), 90% of whom are residents in rural areas with a high (nearly 80%+) reliance on public health system (NSS, 2017-2018). The hospital studied was located in a district that is the second most populous district in the state and provides tertiary care to its approximately 0.17 million residents (General, 2011) in its catchment population. The hospital has a daily outpatient load of 1800 and approximately 200 tests were reported as being done every day at the microbiology lab in 2019. The introduction of the digital monitoring of the ABR project is reflective of this proactive mindset and policies of the State which has actively embraced the use of digital technologies in the health sector. The tertiary teaching hospital introduced the digital application to monitor the Antimicrobial Susceptibility Test (AST) results at their microbiology lab based on an open-source digital platform (called DHIS2, see dhis2.org) in 2019. DHIS2 (District Health Information System) is a free and open-source platform with a flexible data model allowing easy and rapid customization based on local informational needs.   The

hospital under study, typical of most public hospitals, has limited experience with digital systems and suffers from constraints of weak diagnostics, limited capacity, manpower, and infrastructure (Sahay et al., 2020), with information on antibiotics prescriptions and consumption currently largely invisible.

2.3   Data Collection

The process of data collection includes three streams of work. The first was an empirical study (March – April 2020 and July 2021) to understand patterns in antibiotics prescription by physicians at the hospital under study. The second (November 2018-January 2021), and parallel to the first stream of work, was the ongoing process of the design and implementation of the ABR digital reporting system, and the third was efforts to routinize the use of the system. The first stream of work helped in the understanding of the prescription, consumption, and use of antibiotics and the information practices around AST testing and reporting to guide the design of the digital ABR monitoring system. The data collection for the second stream started in November 2019 when the ABR monitoring application was introduced to the microbiology lab at the hospital. The process of system building was inspired by the Action Design Research approach (Sein, 2011), where processes of design, implementation, and use were seen to unfold in parallel rather than as sequential steps emphasized by the traditional system development life cycle (SDLC) approaches. The major timelines and the empirical approach followed are shown in figure 1.
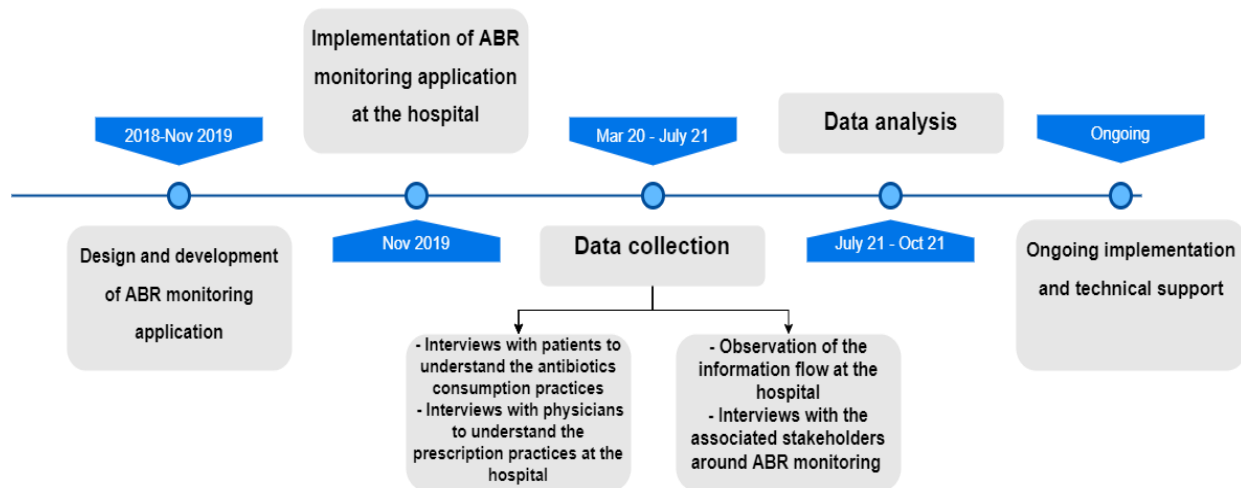

Figure 1. Project Timeline

The data collection process included i) a study of the practices of antibiotics consumption by the patients visiting the hospital and prescribing practices by the physicians; ii) observations of the information flow (both manual and digital); interviews and discussion with the hospital stakeholders, with a key focus on the microbiology lab, to understand the practices around sample testing, starting from the arrival of the patient at the hospital, the physician ordering for the AST, sample collection, sample transfer, testing at the lab, documentation, dissemination, and data use. This empirical work fed into the design and implementation of the ABR monitoring system and its routinization in the everyday practices of the microbiology lab technicians. The data collection methods for three stages i) building of the rich picture of the requirements; ii) design and implementation of the ABR monitoring system based on the rich picture identified; iii) routinization of the digital reporting system are summarized in table 1.

Table 1. Data Collection Methods

Data collection methods	Building the rich picture	Design and implementation of ABR monitoring system	Routinizing of ABR monitoring system
Interviews	Physicians/Head of departments (HODs) – 13 Pharmacists – 4 Patients waiting in queue -10 Microbiologists – 5 Lab technicians- 3 Principal of Hospital	Staff at registration and billing counter – 2 Staff at sample collection unit responsible for collection and transfer – 2 Pharmacists – 4 Microbiologists – 5 Lab technicians- 3	Continuous and ongoing interaction with Microbiologists, Lab technicians, DEO at the lab and Hospital management.

		Data entry operator (DEO) at the lab – 1	
Observation	Physicians while prescribing; pharmacists while dispensing; observation of data management process at microbiology lab, billing and sample collection processes	Data management practices at microbiology lab; billing and sample collection practices; DEO while entering data in the application	On-going
Discussion	With the microbiology team, physicians, and hospital management	With physicians, microbiologists, staff at the microbiology department, and Principal	
Workshop		Requirements analysis workshop	Implementation and post-implementation workshops with stakeholders at the hospital and other public hospitals in the state.

Semi-structured, open-ended guides were used to conduct in-depth interviews with patients and physicians to understand antibiotics consumption and prescription practices. The information flow at the hospital was observed and the associated stakeholders i.e., pharmacists, microbiologists, lab technicians, and data entry operators were subsequently interviewed to understand the workflow at the billing and registration department, sample collection unit at the hospital, microbiology lab, and the use of the outputs generated at other departments in the hospital by physicians and the hospital management. Discussions were held with staff at the microbiology lab to better understand how information around antibiotics was represented in the AST sample recording, testing processes, data collection, analysis, and use. Discussions were also held with the principal of the hospital to understand the antibiotic policies, guidelines, and the hospital's plans to institutionally tackle ABR. Policy documents, both national, state-specific, and hospital-specific were important secondary sources to understand the gap between policy and practice, for example, how the process of prescription audit as suggested by the state was implemented by the hospital. A workshop was held in July 2021 to discuss the implementation process, and issues faced by the stakeholders, and to identify approaches to address them.

2.4   Data Analysis

Data analysis was conducted in multiple sequential steps each for the three stages, described below.

2.4.1   Building the rich picture

This involved the following processes:

Data collation and organization: All data collected including interview notes, observations, and study of documents were organized and collated to facilitate analysis. ***Transcriptions***: All primary data was transcribed and translated from Hindi to English wherever needed, and digitized. ***Thematic analysis and building a rich picture***: First, responses from the patients and physicians were grouped, and major practices were identified, which were then classified as major themes, representing the understanding of the problem. For example, a major theme identified from the analysis of physicians' interviews was the lack of information to decide the antibiotic treatment. Such analysis helped in the building of a rich picture.

2.4.2   Design and implementation of ABR monitoring system

Based on the rich picture constructed, it was identified to develop a digital reporting system that potentially would make available testing profiles to physicians to guide their prescription decisions. The base for generating these testing profiles was the automation of the testing process (called AST – Antibiotic Susceptibility Tests) which was carried out in the microbiology lab. The process included the *initial requirements construction, followed by continuous ongoing and intertwined processes of design improvements, implementation, and regular evaluations.*

The process of ***requirements construction*** included an initial meeting and a workshop to understand the workflow and data practices of the hospital and identification of the team members responsible for communication to aid the development of a requirements specification document. ***System design and development*** followed a participatory approach with the microbiology team actively engaging with the process by providing regular inputs to the design team who responded using a prototype approach.

Testing of each prototype was done by the technical and microbiology teams and upon approval, ***implementation*** was done followed by regular ***evaluations*** of both design and implementation.

2.4.3   Ensuring continued use of the ABR monitoring application

Data collected during interviews, discussions and observation of practices was collected, transcribed, and analyzed to identify the challenges in routinizing the use of the digital ABR monitoring system in the everyday work of users, with a key focus on the microbiology lab. Three major areas were identified for strengthening: i) ensuring timely data entry; ii) enabling improvements in data quality; iii) making test results visible and enhancing their circulation, for example to physicians to help guide their antibiotics prescribing process; and iv) supporting the use of the data for informing policy and practice.

The existing practices and their redefinition throughout the stages of system design, implementation, and routinization were studied based on the concepts of institutional theory, specifically institutional work (Lawrence & Suddaby, 2006) which focuses on understanding how to create, maintain, and disrupt institutions. Based on the analysis, we identified the work needed to translate routinized practices into institutional work. For example, regular assessment of both manual and digital processes was done by both the microbiology and technical teams to identify the institutional work needed to improve data quality through its routine monthly monitoring.

3   Case Study

The case is described in three interconnected steps: i) Conducting a study of the use and prescription of antibiotics and the information flows around AST at the hospital to help build a rich picture of the problem; ii) Ongoing customization, deployment, and support of the digital ABR monitoring system to "make it work" on the ground; iii) Translating of the routinized practices into institutional work.

3.1   Defining Requirements: Building a Rich Picture of the Problem

A rich picture (Checkland, 2000) is a diagrammatic or a pictorial representation of the problem situation. Checkland's soft system methodology (SSM) consists of stages comprised of problem articulation, building alternative system models, and making recommendations for action. It shows the processes and their relationships to each other, actors, communication lines, the tasks being performed, problems that concern the actors, and areas of conflict (Walker et al., 2014). In defining the rich picture, we first identified the major themes from the study of practices around the prescription, consumption, and dispensing of antibiotics. Next, we studied the information practices around the AST process, starting from sample collection, testing, and dissemination of results, to better understand how and whether these testing results served as a guide to physicians in prescribing antibiotics. Taken together, these two streams of empirical engagement helped to develop a rich picture of the problem relating to antibiotics prescription, which served as the basis for the design and implementation of the digital ABR monitoring system at the hospital.

3.1.1   Understanding practices around antibiotic prescribing, dispensing, and consumption

Interviews with patients emphasized that they were largely unaware of antibiotics and how the non-responsible use of antibiotics puts them and their families at risk of developing resistance. Most patients were also seen to be largely unaware of the importance of the physician ordering an AST before writing the prescriptions. Patients generally lacked knowledge about antibiotics and often relied on older prescriptions and their own experiences during past consultations with physicians or took advice from pharmacists. A patient mentioned:

> If the physician prescribes an antibiotics course for 5 days and one does not feel better after 5 days, take the dose for another few days. My dentist gave me an antibiotic for 7 days last time, but I felt I was not cured so I bought the same antibiotic from the pharmacy and took it for 4 more days and I felt better.

Patients wanted to feel better as quickly as possible and did not want to stand in queues for hours waiting for a consultation or in getting tested. They chose the easier option available in case of minor ailments by often using an older prescription or buying an antibiotic without a prescription. A patient waiting in the queue at the hospital said:

> *If I have viral fever, I do not choose to come to the hospital. I take paracetamol for 3 days and if I do not feel better, I start an antibiotic course prescribed by a physician earlier and it usually works.*

Patients did not know about the importance of ASTs and sometimes even did not come back to collect the result. One of the patients mentioned:

> *I cannot afford to come back to the hospital if I feel fine especially to collect the test results a few days after getting medicine from the physician. If the medicine given by the physician works the first time, I do not need to get another medicine or just show my report to the physician.*

3.1.2 Delayed test results

The microbiology lab follows a manual process of testing called disk diffusion which takes 4-10 days from the day of sample collection to the generation of the test report. Sample testing starts on the same day the samples are received (if received before 2 pm), and the process was explained by one of the lab assistants:

> *Once we receive samples at the lab, a standardized technique is followed for AST testing. The samples are put on a culture medium on Agar. These agar plates are then incubated overnight. During the night, the organisms grow on the agar place incubated with test organism and filter paper disc with a specific concentration of antibiotics. The growth is then checked for resistance patterns on the next day. There are specific incubation time ranges for the bacterial colonies as specified by the Clinical and Laboratory Standards Institute (CLSI) which is followed to identify the susceptibility and resistance.*

This duration is too long for the physicians to wait to prescribe an antibiotic, and instead, they would prescribe a broad-spectrum, higher-generation antibiotic while waiting to get the test result and decide to change the treatment plan, if required, provided the patient returned to collect the results. A physician at the hospital mentioned:

> *It takes 3-4 days to get a test result and almost 10 days if it's a blood sample. I can't wait to prescribe an antibiotic for 10 days if I see the signs of an infection in a patient. I prescribe a broad-spectrum antibiotic and wait for the test results. If the antibiotic works I do not change the therapy after getting the report if the patient responds well to the treatment and if not, the antibiotic is changed based on the test results.*

3.1.3 Physicians' considerations in writing prescriptions

Physicians said that they cannot prescribe a culture test to all patients because it is not practically feasible due to high costs and the limited availability of diagnostic facilities and the high patient load they have to cater to. Private testing is expensive and public facilities are limited. Physicians generally ordered a culture test only when patients come to them after multiple prior consultants and courses of antibiotics. Under such circumstances, it was impossible to wait for test results, and a general physician at a hospital told that:

> *A culture test is done when the patient is referred from some other physician or facility and has come after visiting 4-5 physicians. In that case, I give him/her the antibiotic she will be sensitive to no matter what class of antibiotic it is. And sometimes the patients come with small illnesses and in such cases, the test is not done. I prescribe antibiotics because if I won't some other physician will. Sometimes the patient cannot pay for tests, in that case, the patient says I have come for medicines and the physician is sending for tests so she would rather go to some other physician.*

It took many days to get the test results of the samples being tested. If an outpatient is prescribed an AST, he/she submitted the sample on the same day and had to come back in a few days to get the test results from the microbiology lab and go to the physician again to show the reports to get a new treatment plan. Physicians see this time as a limitation and are reluctant in prescribing ASTs. A physician mentioned:

> *I cannot wait for 8 days to prescribe an antibiotic treatment. Most cases coming to the hospital are referred cases, so antibiotic treatment becomes essential.*

Another physician at the hospital mentioned:

> *An AST is generally prescribed to patients who come with severe symptoms/infections. Some of these patients have consulted many physicians earlier so a broad-spectrum antibiotic is*

prescribed, and an AST is ordered. These patients with severe infections are in many cases admitted to the hospital for further treatment.

In the absence of a systematic evidence base, physicians prescribe the antibiotics based on the observed success rate of the antibiotics and their prior experience. A physician at the hospital mentioned:

I cannot ask all patients to get a lab test done here. Most people do not come for consultation because of the fee and take drugs from a pharmacist and self-medicate. If AST is prescribed to all patients, they would rather go somewhere else. In most cases, antibiotics are based on the success rate of the drugs seen in clinical practice the antibiotics are prescribed.

3.1.4   Understanding the practices around AST testing and reporting

The hospital under study did not have prior experience with digital systems. The process of recording patients' data, testing samples, maintaining records, and sharing reports with patients and physicians was manual and time-consuming. A microbiologist said: mentioned:

Once the test results are ready, they are documented on paper and in the register. Patients or their attendants come to the lab to collect the results, the rest of the test results are kept on a table once the lab closes every day at 15:00 for patients to come and collect themselves.

The lab technicians at the microbiology lab complained about the quality of the information received in the requisition forms with samples to be tested. These forms were frequently incomplete with missing patients and sample details. The form had a code of the sample that was mentioned on the vial containing the sample and the name of the patient. However, other details like the department where the patient is treated, his/her diagnosis, and many other related fields were often blank. All of these issues added to the delays in getting test results. The microbiology lab found it difficult to document and sometimes even test such samples with the basic information being unavailable. A sample requisition form is shown in (Appendix, figure 1). A lab technician mentioned:

It is really difficult to test because of incomplete information. Sometimes the sample type and the patient's CR number (unique number) are missing in the form. It is not possible to start the test without these basic details and the sample is sent back to the collection unit for more information.

The hospital did not have existing antibiotic use or infection control guidelines to guide physicians to prepare the treatment plans. During the discussions, the head of the microbiology department said:

We have all the data lying in registers and these registers are not digitized. Whenever someone asks for some information on a particular pathogen, we look at the registers and collect information from them, and share. To develop an infection control or an antibiotic policy, a huge amount of analyzed data from all pathogens is needed which is not available right now.

The microbiology team was initially unable to generate an aggregate report to be shared with the hospital management and state authorities, due to the manual and fragmented nature of data records. A microbiologist at the hospital said:

It is impossible to generate a report with the data in the registers. We can count estimates based on the data for specific pathogens but a holistic analysis of the test results is impossible to generate with manual analysis. There are three registers each for Blood, Urine, and all other samples and to prepare an aggregated report the data from all registers need to compile separately and then aggregated.

Another microbiologist at the lab mentioned:

Finding relevant data manually from all the registers and then aggregating them together from all registers is a tedious exercise. The team does not have the time to do this task and there is already a manpower crunch at the lab. We only have two lab technicians who do all the work, and they need to stay overtime to start the culture for the samples received later during the day. Data analysis becomes secondary when there is a huge daily task that needs to be done.

Limited capacity and resources added to the existing challenges of delayed test results. Largely, we learned that the practices of the non-responsible use of antibiotics were shaped by poor awareness and knowledge and limited counseling by the physicians, free availability of antibiotics over the counter without prescriptions, and the patients' need for quick fixes and inexpensive remedies. The prescription practices of antibiotics and AST tests by physicians are shaped by high patient load, poor capacity, and lack of

timely AST results to guide the prescriptions. Based on the observations, interviews, and discussions with all the stakeholders, a rich picture (Checkland, 2000) was created to articulate the problem situation (figure 2). The central problem identified was the lack of a systematic and timely evidence base for physicians to guide their prescription decisions. The different conditions identified from the two streams of empirical work are depicted in the rich picture below.
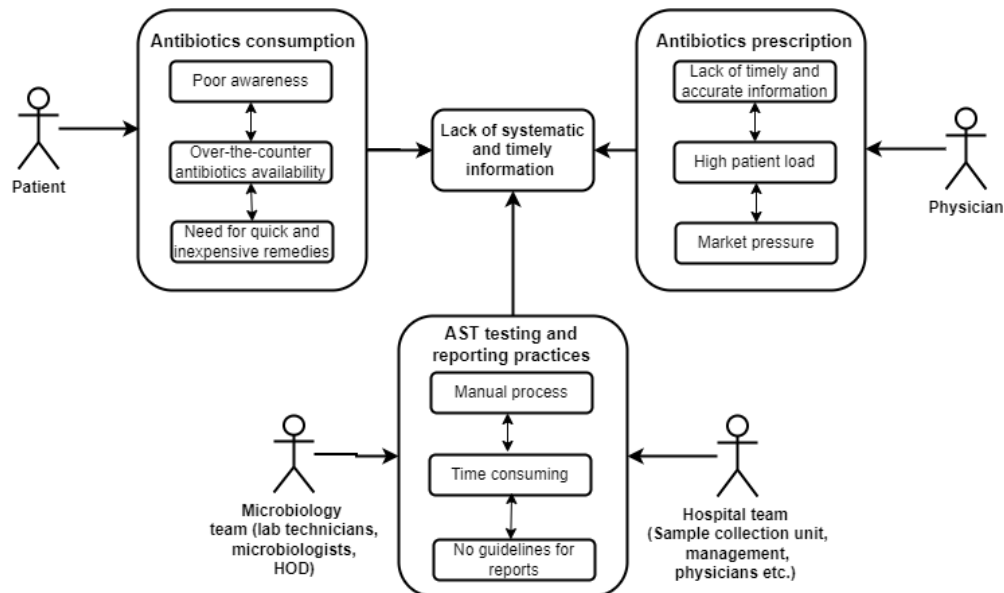

Figure 2. A Rich Picture of the Problems Around ABR Monitoring at the Hospital

These challenges have taken together highlight the bigger problem of the unavailability of timely and actionable information for physicians to guide the prescriptions. To try and address this central problem was to develop a digital ABR reporting system, and incrementally seek to redesign information practices to support the use of data on test results to support prescribing practices. The process to guide this intervention is now described.

3.2 Ongoing Customization, Deployment, and Evolution of the Digital ABR System

The process of ABR monitoring system design and implementation started in 2017-2018 by HISP India in which the first author was deeply involved along with the technical team at HISP India. An application was designed earlier in 2017 for a national research organization on an open-source platform (DHIS2) that oriented HISP India about the problem of ABR. In 2019, the hospital under study was approached to design and use the application to manage their ABR data. The application developed for the research organization focused on aggregate reporting for regional monitoring which needed to be radically redesigned for supporting the microbiology lab work in collaboration with the microbiologists. A microbiologist said on seeing the original application developed for the research organization:

> I want to see all the samples collected for each patient and the organism identified from the sample with the lab details on the main screen else, it is very difficult to search multiple samples collected for a patient and the organisms identified in each sample.

The technical team realized the need to radically reconfigure the original application to one which is patient-focused and specifically supports the lab work. An initial meeting was organized with the hospital management and the microbiology team to demonstrate the initial application and a process was initiated to specifically define lab-specific, requirements to address the key problem identified in the rich picture. However, the hospital and the microbiology team had limited knowledge, capacity, and experience with digital systems and found it difficult to articulate their requirements for the application. A process of "learning by doing" was used to detail the workflow, information flows, and expectations from the monitoring application. The information flow as we understood it is schematically depicted in Figure 3.
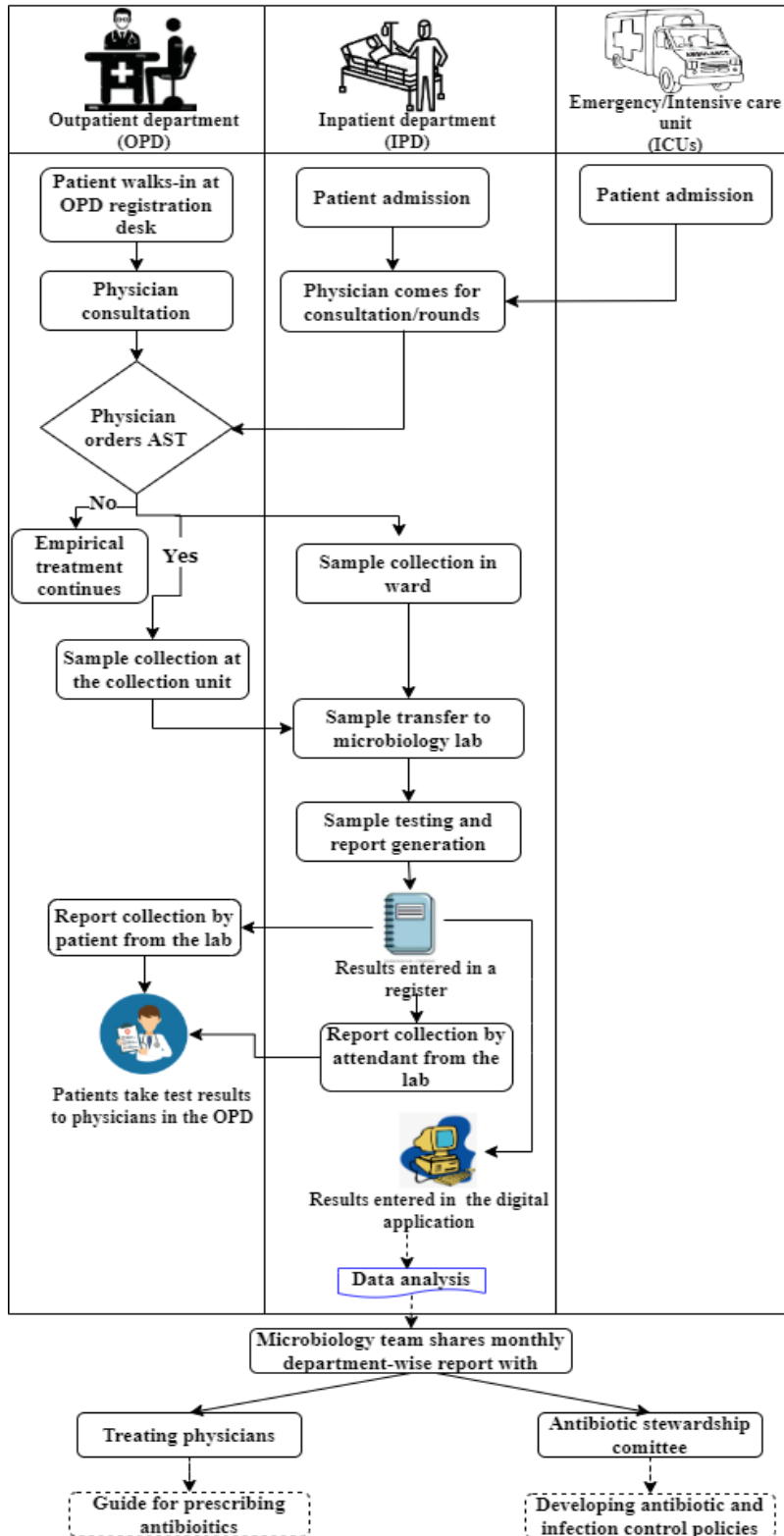
Figure 3. Information Flow Among Hospital Departments Around ABR Monitoring

The lab technicians at the microbiology lab maintained a manual register with a record of the patients' details and all the samples received at the lab daily. The test results were entered against the patients' names once the testing process was completed and a manual report was given to the patient/attendant.

Existing data in the registers were not subjected to systematic analysis for resistance patterns because of the manual nature of testing records and the incompleteness of information.

To start the operations with the existing prototype, end-user training was organized for the microbiologists and the data entry operator. The lab arranged a computer to initiate data entry which was placed next to the table where they kept the manual registers to facilitate the process of data entry. The hospital did not have the resources to hire a full-time data entry operator, so they assigned two part-time data entry operators from the general registration desk of the hospital who took turns coming to the lab for two hours in the afternoon after finishing their routine work. Often data entry backlogs remained as the operators skipped coming to the lab as they were held up with their primary work at the registration desk. All the while, the implementation team from the HISP India team had weekly meetings to evaluate the current system, and actively seek suggestions for systems improvement from the different staff in the lab. These discussions and observations helped to jointly identify how system improvements could be introduced, and these requirements were rapidly converted into usable functionalities by the software team of HISP India.

In parallel to the above processes, the HISP India team started to develop a "systems requirement document", which would be live and evolving. Unlike traditional information systems development projects, this document was not the starting point for system development but evolved through the ongoing interaction processes of understanding requirements, design, and deployment. The design team used a prototyping approach, which included the development of a roadmap with details of each prototype; building the prototypes and sharing them with the microbiology team for their feedback; merging the prototype with the live application after user testing and conducting refresher training to build capacity on an ongoing basis.

The configuration, deployment, and capacity building were treated as ongoing parallel activities, and the microbiology team shared their new requirements as they experienced and used the existing features. The feasibility of these requirements was discussed between the technical and the microbiology team, agreed upon, converted into system features, tested by both teams, and updated in the production instance of the application. For example, the first release cycle included minor configuration changes like the addition of new data entry fields, changing the existing fields, and adding additional sample types, organisms, and antibiotics in the metadata. The second prototype included the development of new reports, graphs, charts, etc for specific organisms and sample types, configuring them in the dashboards, and sometimes building new modules like infection control and the development of reports like department-wise resistance reports.

As a part of ongoing evaluation and to scale the use of the application, a workshop was held in Feb 2021 to collaboratively i) discuss how to use the generated reports to guide the physicians to write prescriptions; iii) understand the possibility of scaling the application to other public teaching hospitals in the area. After many rounds of discussions, it was decided to develop an aggregate report with department-wise trends of resistance[1], which could potentially help physicians to decide on the antibiotics to be prescribed based on the patterns highlighted in the report. With this report, the team identified that physicians could make better evidence-based decisions, even in the absence of the test results. For example, if a lower-generation antibiotic was seen to be susceptible in 90% of cases, the physicians could start the treatment with a first-generation antibiotic rather than a higher-generation one. This was followed by a discussion between the physicians, microbiologists, and the design team to discuss the requirements for such a report, and with a few iterations, the report was finalized and is now in regular use at the hospital. A department-wise report is displayed in Figure 4.

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[1] Resistance trends

Total no. of isolates (1/patient)	Location	%/N Per Location	Amikacin (B)	Amoxicillin/Clavulanic acid (B)	Sulbactam Ampicillin- (B)	Cefepime (B)	Cefixime	Cefprozil	Ceftazidime (A, B, C)	Ceftriaxone (B, C)	Cefuroxime (B)	Ciprofloxacin (B, C)	Colistin	Doripenem (B)	Doxycycline (B)	Gentamicin (A, C)	Imipenem (B)	Levofloxacin (B, C)	Meropenem (B)
Escherichia coli (N=464)	Ward	29.31 136	69.05 (29/42)	55.20 (69/125)	(7/11)	(7/10)			(6/8)	(1/14)	(2/5)	(3/6)	(1/1)	(3/3)	28.13 (9/32)	(3/3)	(8/9)	(7/21)	(2/3)
	OPD	57.11 265	95.88 (93/97)	72.20 (174/241)	(15/20)	(9/15)	(6/18)	(2/2)	(10/16)	(9/14)	(9/15)	(3/17)		(3/4)	61.11 (22/36)	(8/8)	(10/11)	59.18 (29/49)	(14/17)
	CCU	0.43 2	(1/1)														(1/1)		
	Unknown	12.50 58	(13/14)	58.18 (32/55)	(2/3)	(4/4)			(1/3)	(3/10)	(1/6)	(2/6)			(1/2)		(2/2)		(1/3)
	ICU	0.65 3	(1/1)	(3/3)	(1/1)														
	Ward	35.71		44.12															

Figure 4. An Excerpt from the Demo Department-Wise Report

3.3   Ensuring continued use of the ABR monitoring application

The process of the routinization of the use of ABR monitoring application as a part of the everyday workflow of the stakeholders is a continuous ongoing process for establishing routines. The technical team first focused on establishing the data entry processes, bringing improvements in quality, followed by the development of outputs, and enhancing its circulation in the hospital. These are now described in detail.

3.3.1   Ensuring timely entry

The data entry module allows patient registration and maintenance of a patient record and associating the test results with this record (Appendix, figure 2). The test results are entered against the antibiotics in numerical values indicating the resistance patterns. The results are classified as R- Resistant, I – Intermediate, and S- Susceptible based on the numerical value entered and predefined logic stored in the application based on global guidelines. The data entry fields turn red, yellow, and green respectively for R, I, and S once the results are entered (Appendix, figure 3). This information is used as a criterion to determine which antibiotics are likely to be most effective in treating the infection. A resistant result indicates, that if the tested antibiotic is prescribed, it will not work against the identified bacteria and will not be able to treat the infection. A sensitive test result indicates that the tested antibiotic will be effective against the bacteria if prescribed while an intermediate result indicates the antibiotic dose needs to be adjusted for it to be effective against the infection. Prescription of the first line of the sensitive antibiotic is an appropriate choice of treatment to treat the infection and to reduce the risk of the development of antibiotic resistance in the patient. The test results are automatically aggregated based on pre-defined parameters and can be viewed on the dashboards. The dashboards provide real-time access to various patients', organisms, samples, and antibiotics-wise reports in one place. A screenshot of the dashboards is shown in (Appendix, figure 4). Additionally, a department-wise report with monthly and quarterly trends of resistance has been developed. Both hardcopies and softcopies of this report are sent to the Head of Departments to guide physicians to prescribe evidence-based antibiotic therapy. For example, if a lower-generation antibiotic is susceptible in 90% of cases, the physicians can start the treatment with a lower-generation antibiotic rather than a higher-generation one to reduce the risk of developing resistance. Upon initiation of the data entry at the microbiology lab, several operational and technical issues were identified, which led to the development of a new data entry App, which largely mimicked the manual registers.

Capacity building: The microbiology department had a server manpower crunch, and they could not have a dedicated person but relied on the common pool of hospital staff. A desktop with an internet connection was set up on a table in the microbiology lab next to the table where the registers are kept. The operator had no experience working in the microbiology department and was new to the terms used, and often needed help from the lab assistants. Some problems were also experienced with the regularity of the operator since this was not his exclusive responsibility. He told us:

> *I come to the microbiology department after getting free from the registration desk. Sometimes, I cannot come to the lab when I have pending work at the desk because that is my primary duty at the hospital. In the lab, I copy and enter the details written in the register into the digital application. Sometimes, I do not understand the terms and handwriting in the register and ask the lab assistant for help.*

He was mandated by the hospital principal to come to the lab once he was free from his work at the registration desk in the afternoon. Often data entry backlogs remained as the operators skipped coming to the lab when they were held up with their primary work at the registration desk. To facilitate smooth and uninterrupted work, a full-time data officer was hired by the HISP India team who not only did regular entry work but also did an analysis of data quality by checking the manual and digital data to identify and rectify discrepancies. He also acted as a coordinator between the technical and microbiology teams, to ensure new requirements were better understood and rapidly implemented. Since he was unaware of the microbiology terminology and codes used, the lab prepared a sheet with codes (Appendix, figure 5). and the names of the antibiotics, which were pasted on the wall next to his desk. Another sheet was prepared with a list of codes of the departments (Medicine, Surgery, Orthopedics, etc.) and locations (OPD, IPD, ICU, Ward, etc.), which needed to be entered digitally.

Identification and resolution of operational issues: The technical and microbiology teams had regular meetings to evaluate the implementation and use of the digital application. During one of the on-site meetings, it was identified that often the data entered in the register by the lab technician is illegible and incorrect. After using the digital application for over a year, the microbiology team also identified some essential fields that needed to be recorded to conduct a more meaningful analysis. For example, the manual registers (Appendix, figure 6) did not have the fields to capture the department, and location and they needed to reduce the space to capture yearly, monthly, and daily numbers to fit the long CR number. *As an effort to standardize incoming data,* the microbiology team decided to design stamps with a predefined list of antibiotics for each sample and organism to be printed in the register to minimize manual data entry by the lab technicians and to maintain data quality. The microbiology team decided to change the format of the manual registers and reprint the registers to capture the necessary information after finishing their existing printed stock of registers.

3.3.2 Enabling improvements in data quality

This information in the requisition form was also required to be entered into the digital ABR monitoring application to generate a department-wise antibiotics susceptibility report. Since this information was largely incomplete, accurate data analysis could not be done that could be sent to the treating physicians. To overcome this constraint, the microbiology and the technical team jointly sought to improve the data quality, for example by designing and developing a monthly report (table 2) with details of the missing information received at the lab for each sample type.

Table 2. Record of Missing Fields in a Month in 2021

Data fields missing/incorrect	Blood register		Urine register		General register		Overall %
	Number	%	Number	%	Number	%	
Hospital Department	68	25	105	21	260	52	34
Location	50	18	95	19	258	51	32
Computer Registration number	1	0.4	0	0	0	0	0.1
Age	1	0.4	9	1.8	1	0.2	0.9
Wrong Computer Registration Number	10	3.7	14	2.8	0	0	1.9

The microbiology team used this report as evidence and took it to the medical superintendent of the hospital to drive actions at the administrative level to improve data quality, such as: training the interns at the lab to collect samples at the sample collection unit. They were microbiology graduates completing mandatory monthly duties at the lab as a part of their course. These interns would go to the sample collection unit to collect all samples themselves and write all the necessary details on the requisition form to facilitate completeness and accuracy of data. ii) The microbiology team changed the format of the requisition form where they highlighted the mandatory information that needed to be filled. iii) The report generated provided the microbiology team with the necessary information to drive the change at an administrative level. The letter written by the microbiology team to the superintendent and the new requisition format is shown in (Appendix, Figures 7 and 8). These interventions led to significant improvements, as shown in the data quality report generated two months after the intervention (see table 3). The generation and use of such a report by the microbiology lab have now become part of their monthly monitoring routines.

Table 3. Record of Missing Fields After

Data fields missing/incorrect	Blood register		Urine register		General register		Overall %
	Number	%	Number	%	Number	%	
Hospital Department	3	2	14	2	52	11.7	6%
Location	1	1	15	3	55	12	6%
Computer Registration number	0	0	0	0	0	0	0%
Age	0	0	3	0.5	0	0	0%
Wrong Computer Registration Number	23	12	63	10.7	48	11	11%

3.3.3 Making test results visible and enhancing their circulation

The earlier generation of a quarterly susceptibility report was done manually by aggregating data entered in the registers, by the head microbiologist at the department with the help of resident physicians and post-graduate students. The cumbersome and error-prone nature of this process was described to us by a microbiologist:

> *It used to take us weeks to count the numbers from the register and prepare a report. Sometimes, we even skipped developing this report because it was cumbersome and practically impossible to count several figures and document them correctly.*

The ABR monitoring application has helped the department to prepare such a report easily, correctly and on a monthly and not quarterly basis. The case-based data entered in the application is aggregated automatically and presented on the dashboards based on the reporting requirements. Additionally, a department-wise report (figure 4 above) that can be downloaded and printed by the microbiologists is also developed which is sent to the treating physicians to help their prescribing practices. The report was further checked in relation to the manual registers, which helped to identify that certain antibiotics being tested for some organisms were not needed. It was observed that this happened because the lab did not have a standard list of antibiotics to be tested for each sample type and organism detected. The microbiology team then formed an internal committee to look at global and national guidelines to develop a list of standard antibiotics to be tested for uniform and meaningful reporting.

Standardizing information and its use in patient care

The process of sending a hospital-wise report sent by the microbiology department to the treating physicians was initiated in August 2021. However, an evaluation of the active utilization of the report to write evidence-based prescriptions is in the process of being done. Several initiatives by both the microbiology and hospital teams are being taken currently to promote the use of this report.

Sharing resistance profiles with the stewardship committee at the hospital and the state: As per the national guidelines, all public hospitals were mandated to form an antimicrobial stewardship committee. The hospital formed a committee in October 2021 which is led by the Head of microbiology and includes members from other departments such as Medicine and Surgery. The committee meets every month and the HOD microbiology presents the monthly resistance profiles downloaded from the ABR monitoring application to the members. The committee has decided to use one year of resistance profile reports data

to develop an infection control and antibiotics use policy for the hospital. Additionally, the hospital shares a monthly resistance profile with the ABR coordinating center in the state.

Discussions with the treating physicians*:* Another strategy adopted is to meet the treating physicians personally to promote the use of department-wise reports for evidence-based prescriptions. The research team along with a senior resident of the microbiology department met various treating physicians from different departments. During these meetings, they showed a sample quarterly department-wise report with resistance profiles and asked the physicians if they found it helpful and solicited feedback to improve the report, which helped to make improvements to the report. A Gastroenterology consultant mentioned:

> *I always wondered if I had such a report available while prescribing, I would have an idea of what antibiotics are susceptible and resistant in the area. Currently, we prescribe a second or third line of antibiotics during the first consultation, but it is better to prescribe the first-generation antibiotic if it is susceptible in almost 80% of cases as I see in this report. However, I did not think anyone would take an initiative to make such data available at a public hospital.*

Sensitizing junior and senior residents about local resistance profiles: Being a teaching hospital, a majority of the daily caseload is attended by junior and senior residents in the outpatient and inpatient departments. The microbiology department has taken an initiative to call regular meetings with these residents to sensitize them about the local resistance profiles and the availability of reports to promote evidence-based prescriptions.

Scaling of practices within and across hospitals: The learning from the hospital is now also being shared with neighboring hospitals. A workshop was organized at the hospital in July 2021 and was attended by all departments of the hospital and also the microbiologists from some of the neighboring public hospitals. The microbiology team presented their learnings and experiences of using the digital application which was well accepted and appreciated by the participants. One of the nearby hospitals decided to take up the application, and could significantly compress the timeframe for implementation because they did not need to reinvent the wheel. In a follow-up workshop organized in July 2022, a nearby hospital reported that data entry was in full swing and in the process of being routinized. In the original hospital, the discussion amongst the department heads focused on how to use the reports more effectively, particularly for patient care and policy making. It was decided that the hospital stewardship committee will lead the activity of the development of the policy. All departments were directed to develop a department-wise guideline based on the reports they receive and submit it to the department of Pharmacology. The chief pharmacist and team were made responsible to develop and present a hospital antibiotic policy in consideration of the guidelines shared by all departments. The microbiology team also presented a need for training of the interns on proper sample collection techniques, at the beginning of their internship period.

4   Case Analysis and Discussion

The case analysis presented based on the analysis of information practices guided by concepts from institutional theory. We describe the routinization of information practices shaped by their ongoing definition, redefinition, and evolution throughout the stages of system development, implementation, and use of data. The institutional theory offers relevant concepts to study the organizational responses to the changes enabled through digital intervention. IS researchers have studied technology adoption, such as the technology acceptance model (TAM) and the Unified theory of acceptance and use of technology (UTAUT) (Gopinath et al., 2022; Lee et al., 2003; Silvestre et al., 2022). While these models provide insights into the behavioral intentions, attitudes, and performance expectancies of users, they tend to be decontextualized and not considering the institutional setting. Our incorporation of institutional theory concepts into IS research studies related to requirements analysis helps to understand how such adoption processes are shaped by nonlinear routes (Currie, 2009). We bring together concepts from IS research and institutional theory that guide the presentation of the case analysis. Translating practices into stabilized institutional work requires continuous and ongoing efforts to bridge the gap between the formal institutions (mandating the use of the digital intervention) and the informal constraints experienced (such as capacity and infrastructure) in the materialization of these formal institutions in practice. Analyzing this bridging work helps to understand the challenges experienced in the stabilization of work and the approaches to address them.

The case analysis and discussion are presented with two interconnected components. The first concerns the introduction and routinization of new practices that the digital intervention enables (in 4.1), and the second concerns the processes by which these are translated and stabilized into institutional work (in 4.2). To enable this translation, there is an ongoing bridging of the gaps between the formal institutions being mandated and the constraints experienced in making these work in practice and becoming stabilized as institutional work. This is described in 4.3. Finally, the conceptual framework from the discussion is depicted in figure 5 with our key findings.

4.1 Routinizing Work Practices

Practices represent "shared routines" (Whittington, 2006) or "recognized forms of activity" (Barnes, 2001) that guide behavior. All institutions have a set of practices and organizing principles that provide the logic of the actions of actors as they respond to their work demands (de Certeau 1984), which go to reproduce and evolve institutions (Suddaby & Greenwood, 2005). Such an analysis is guided by a practice lens, which has been used in IS research in different ways such as a perspective, method, and philosophy. The practice lens is oriented toward understanding the recursive interaction between people, technologies, and organizational routines, being shaped within a situated context (Orlikowski, 2010). Such a perspective emphasizes that technology is not treated primarily as a standalone artifact but as an integral element of people's routine work and the lived character of their everyday world, which serves as the object of analysis (Lave, 1988; p18). Routines represent "*a repetitive, recognizable pattern of interdependent actions, involving multiple actors*" (Feldman & Pentland, 2003, p. 96). Technology becomes institutionalized in organizations when it becomes a part of the everyday routines and work of the actors. Our case analysis focuses on understanding how the digital ABR monitoring system becomes part of the everyday routines of actors engaged in AST work in the microbiology lab and then gradually starts to percolate into the practices of other stakeholders, such as physicians and hospital administration. This process of routinization involves creating, maintaining, and disrupting institutions, which becomes a focus of this analysis.

The introduction of digital technologies into a workplace experiences both acceptance and rejection by users and the organization, which often change over time. These responses arise from the interplay between people, their work, and technologies within situated contexts (Orlikowski, 2010). Institutions represent organized, established procedures that reflect a set of standardized interaction sequences (Jepperson, 1991), which influence processes of institutional change, innovation, and deinstitutionalization processes. There is an ongoing "duality of work" (Giddens, 1984), representing the mutual interconnections between practices and institutions (Battilana & D'Aunno, 2009), which can be both visible and invisible. These interactions lead to the creation, maintenance, or disruption of institutions (Lawrence et al., 2009). We now describe how these processes played out in the context of the case, in the context of i) data entry stabilization and improving data quality; ii) generation and circulation of relevant outputs; iii) using data to inform policy and practice. While the first practice relates to the input side of the reporting system, the second concerns the output side of generating and circulating reports from the system. The third, undoubtedly the hardest, concerns the practice of using data to inform policy and practice.

4.1.1 Data entry stabilization and improving data quality

An initial key challenge concerned the digitization of data entry work, which represented something new, and needed to replace deeply embedded manual recording processes. Digitization involved the building of new routines, such as the coming of the data entry operator every day between 2-4 pm to the microbiology lab to do the data entry. This represented creating institutional work and maintaining it, while also disrupting some existing institutions, such as gradually reducing reliance on the manual registers (Lawrence & Suddaby, 2006). The technical team of HISP India worked in collaboration with the microbiology staff to create new forms of work (such as hiring a dedicated data entry operator), making improvements in data quality (by building a data quality report), and training the microbiology team to generate these reports to institute a new practice of monthly data quality review.

There was creating work done by defining roles and allocation of responsibilities and training the data entry operator to conduct data entry work more efficiently than before while incrementally bringing in improvements to quality. The data entry app was so designed so as mimic the existing manual systems (formats carried in the registers), which allowed the continuity with existing systems while bringing in a new form of managing data through digitization. Maintaining work was done through authoritative institutional measures of the data entry operator being administratively controlled by the microbiology

team, such as the times of starting and ending work, and by creating job aids such as pasting sheets with antibiotic codes, names, and departments on the wall next to the operator's desk (Appendix, figure 5). HISP India's hiring of a full-time dedicated data entry operator, represented a form of disrupting work, in that it enabled eliminating reliance on the use of the internal hospital data entry staff, which was often irregular and inconsistent, and helped the strong routinization of the everyday data entry work.

With this stabilization, new practices started to be created such as the conduct of regular analysis of data quality, which provided the impetus for microbiologists to conduct more granular microbiological analysis of the AST data. To support this process, they advocated to the hospital administration to change the format of manual registers by including additional details such as department name and location. They also approached the head of the hospital to enforce new regulations, such as not accepting samples for testing if they were not accompanied by properly filled sample testing requisition forms. Medical interns were trained and tasked with the responsibility of having the clinicians to fully complete the forms and only then collecting the samples. The creation of these new practices contributed to maintaining higher levels of data completeness and quality and helped spread awareness about ABR digitization in the hospital.

4.1.2   Generation and circulation of relevant outputs

With the increasing routinization of the practice of data completion and quality control, the attention shifted to the outputs which could be generated from the system. The initial focus was on creating routine reports, such as charts, graphs, and tables to highlight the sensitivity and resistance patterns (see appendix, figure 3 for some sample outputs). Initially, the use of these reports was largely confined to the staff in the microbiology lab. However, as the staff gained confidence in the quality and veracity of the reports, they started to demand from the technical team more complex and comprehensive reports, which they could share with other stakeholders in the hospital. This gave birth to the generation of a "department-wise susceptibility report" (see figure 4) and with it a new practice of sharing the report with the physicians and hospital management. This represented a disruption of the existing practice of the testing data being confined to the microbiology gap and largely invisible to the rest of the hospital and the creation of a new practice of the digital circulation of reports across the hospital.

Supporting the creation of this new practice, was the technical work done by HISP, who in active collaboration with the microbiologists, designed, developed, and deployed this complex report, which involved multiple iterative cycles and took nearly 6 months to make fully operational. The technical team was continuously involved in clearing the bugs and improving the quality of reports and making them increasingly more accessible to users through the dashboards. The microbiology team could now independently download the reports and start to use the outputs for supporting their routine practices around the generation and analysis of the AST results. Everyday work was maintained and repaired through continuous communication between the microbiology and HISP teams, using online media of Zoom, WhatsApp, and weekly calls, where issues were highlighted and swiftly addressed. In this way, new practices, such as forms of analysis and reviews, were continuously created, which were gradually maintained through reliable back-end technical support and improvements in data entry and quality. These processes helped build confidence in the microbiology team to embark on new analysis efforts and raise their voices in departmental meetings on issues of quality of forms and processes of sample collection.

4.1.3   Using data to inform practice and policy

As processes of data entry, output generation, and their circulation in the hospital were enhanced, there was a rising level of motivation amongst the microbiology staff as they saw their voices were now being heard in departmental meetings in the hospital and also beyond. In the February 2021 workshop, which was attended by the hospital staff, the HISP technical team and researchers, and also microbiologists from nearby hospitals, the team proudly presented their work and the progress made with respect to ABR monitoring and reporting. A couple of the nearby hospitals also agreed to introduce similar systems in their respective labs. In July 2022, there was another similar workshop, where the microbiologists presented the progress made over the last year, and the organization-wide department report now being generated was distributed to all participants. A vibrant discussion was enabled over this report, which initiated a process of "conversations around data", which arguably is the first and foundational step in making use of data to inform practice and policy. The hospital administration was emphatic that such reports should be the basis for data use by clinicians and also for hospital administration, such as to guide antibiotics procurement. Some of the clinicians did not agree with this policy direction, saying that the

reports come too late to be useful for them in defining empirical therapy. Some others said that they had not seen the reports as they had been sent to the head of the department, who in some cases had not opened their emails and transmitted them to the physicians in their department. Other physicians raised concerns about the adequacy of the essential drug list mandated by the State, and their clinical needs do not correspond to that. The pediatricians argued that their clinical therapy for them is very different from that of other specialties, which made it difficult for them to adhere to common hospital policies. The microbiologists saw this as an opportunity to raise the need for automated testing systems to reduce the time lag in generating and distributing the test reports.

The overall outcome of this process of initiating "conversations around data" was positive, as a consensus was reached that the hospital needs a "locally relevant data-driven antibiotics stewardship policy". In the hospital stewardship monthly meeting, that took place the day following the workshop, the HISP India team was also invited to attend, the organization-wide report was further discussed. It was agreed that the hospital pharmacologist will be responsible for coordinating this process of antibiotics stewardship management policy development, and the HISP India team would support him by discussing with different departments their data needs and how the digital system could satisfy these needs. The Pharmacologist was asked to present progress after a month. The HISP India team, on their part, also started to study other similar initiatives of policy development in other states and initiated processes to introduce other experts into the process so that relevant best practices could be sensitively adapted. While this process has been initiated, it is something that will reach fruition in a matter of years and not months, as it involves a radical process of transformation, technical and institutional. This is complex to achieve given the history of manual systems, high patient loads, infrastructure constraints such as testing capacity, and the varying needs of different clinical disciplines. However, a positive takeaway is that digitally generated data has made visible issues that were not earlier known, and a relative consensus has been reached that data should be treated as a strategic resource in guiding hospital policy and clinical practice. This could be seen as the steppingstone for the creation of new organizational routines that are fundamentally informed by everyday empirical data.

New practices as they get increasingly routinized take the form of institutional work, representing "*the purposive action of individuals and organizations aimed at creating, maintaining and disrupting institutions*"(Lawrence & Suddaby, 2006). *Creating* work describes how new institutions emerge and get established while *maintaining* is concerned with how institutions are actively produced and reproduced through everyday practices and *disrupting* focuses on the development of new routines at the expense of the old (Greenwood, Suddaby, and Hinings 2002). First, we summarize the institutional work framework drawing upon Lawrence and Suddaby (Table 4) and then apply it in the analysis of our case (Table 5).

Table 4. Institutional Work (Lawrence & Suddaby, 2006)

Forms of Institutional work	Types of Institutional work
Creating	Advocacy; Defining; Vesting; Constructing identities; Changing normative associations; Constructing normative networks; Mimicry; Theorizing; Educating
Maintaining	Enabling work; Policing; Deterrence; Valorizing and demonizing; Mythologizing; Embedding and Routinizing
Disrupting	Disconnecting sanctions; Disassociating moral foundations; Undermining assumptions and beliefs

Table 5. Institutional Work for Creating, Maintaining, and Disrupting Institutions

Nature of practice	Changes enabled through the digital system	Mechanisms for routinization of practices
Data entry stabilization and improving data quality	- Data entry App designed by mimicking manual registers to enable a seamless transition to the digital system. - Data quality reports could now be generated which could help identify missing data and corrective action	**(Advocacy)** Regulatory support from hospital administration to make digitization a priority. **(Changing normative associations)** Implementing a new format for the sample testing requisition form to enable a more granular analysis of data and the development of a monthly data quality report which enabled the microbiology team to make evidence-based

		could be identified.	recommendations to bring improvements in data quality. **(Undermining assumptions and beliefs)** A routine data quality analysis convinced the microbiology team to replace register formats to include more details and design stamps to standardize the dissemination of test results.
Generation and circulation of relevant outputs	- Development of outputs in the forms of charts, graphs, maps, etc. reports based on microbiology team requirements -Development of department-wise reports - Regular troubleshooting and continuous improvement in quality of reports		**(Educating)** the data entry operator and the microbiology team to regularly generate and print reports **(Defining)** new practice to send a monthly and quarterly susceptibility report to the physicians and hospital administration **(Undermining assumptions and beliefs)** Physicians seeing some of their inappropriate prescribing practices, such as the efficacy of first-generation antibiotics when they tended to use the third generation.
Using data to inform practice and policy	- Regular maintenance and checks to update the reports - Development of new reports based on the requirements of the microbiology team		**(Valorizing)** Recognition of the work done by the microbiology team **(Enabling work)** Organization of annual workshops to assess the implementation challenges to feedback to improve and starting conversations around the use of data at both practice and policy levels among other stakeholders in the hospital. **(Constructing normative networks)** normative sanction of the practice of making the department-wise report a part of the regular discussion in stewardship meetings.

4.2   Stabilizing Institutional Work

In the context of digital ABR monitoring, there was the need to create new forms of institutional work, which incrementally built upon routines and available capacities (Rao et al., 2011), infrastructures (Vong et al., 2017), workloads (Sahay et al., 2020) and policy environment (Walia & Ohri, 2016). Institutional work helps to understand how information routines need to navigate between the old and new, building new or redefined practices and gradually being translated into institutional work. Our analytical focus was on understanding how practices, defined earlier, became increasingly routinized and were translated or not into institutional work, and what challenges were experienced and addressed. We identified three key mechanisms for enabling this translation: i) establishing the legitimacy of the new practices; ii) building local capacity and ownership, and iii) expanding networks of stakeholders.

4.2.1   Establishing legitimacy

Suchman (1995, p574) describes legitimacy as a *generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms*, *values, beliefs, and definitions.* Legitimacy provides the condition to create and accept institutional work, which allows an organization to evolve its structures, culture, and systems, and build stronger alignment between the organization's expectations and the action of members: *legitimacy is possessed objectively, yet created subjectively (*Suchman, 1995). While building the legitimacy of new digital interventions is a slow process, given its novelty in contexts as described in this case, normative support plays a crucial role in addition to the interplay between regulative and cultural-cognitive dimensions. Legitimization is a continually unfolding process where different scenarios are identified at different points in time, with processes of both creating and undermining legitimacy, taking place simultaneously. We interpreted three sets of processes of legitimacy building: i) increasing recognition of the value of data; ii) responding to regulative demands; iii) the norm of providing better patient care

Increasing recognition of the value of data: (Scott, 2013, p64) defines values as *conceptions of the preferred or desirable, together with the construction of standards to which existing structures or behaviors can be compared and assessed.* In this case, the value of the digital system was initially created by supporting the microbiology team in their everyday work of digitally recording AST data and

then the creation of desired outputs, which were circulated within the hospital and also to the state authorities. These tasks which were previously not possible because of the manual nature of systems were gradually made possible through digitization. Legitimacy was gradually built as the microbiology team was seen as embracing modern technologies, which allowed them to do work that was not possible earlier. Internally in the microbiology team, there was a sense of professional advancement, as they could now engage in what the data said about clinical conditions and not just be wrapped up in the more bureaucratic and mundane tasks of recording and reporting data. This strengthened their self-perceptions of legitimacy. Legitimacy within the hospital administration and other clinical departments was enhanced as they saw the microbiology team engaged with new forms of data-driven practices and could see the value of those outputs for their work.

Responding to regulative demands: Regulative legitimacy is associated with the alignment of new practices with existing rules created by governments or professional bodies (Zimmerman & Zeitz, 2002). Technologies that support organizational conformity to existing rules and regulations possess a higher level of regulative legitimacy than those that do not (Binz et al., 2016). In the case of ABR, research has pointed out significant "policy-practice" gaps, with regulations and policies around strengthening surveillance systems in countries being largely not implemented in practice. As Ouknider (2022) writes:

> *Monitoring and evaluation are contingent on access to data that is then transformed into actionable knowledge. AMR data, whilst gaining ground in terms of collection after the development of global and national action plans is still monopolized by international repositories and remains mostly unavailable to local stakeholders.*

In this case, the availability of actionable data at the hospital level enabled the hospital to respond to the central government mandate of establishing and operationalizing an antimicrobial stewardship committee by using the department-wise reports as a basis to initiate the development of an antibiotic policy. This enabled the hospital to respond to state regulations to procure and prescribe antibiotics listed in the Essential drug list (EDL). The hospital team decided to use the sensitivity pattern of antibiotics from the department-wise report to guide the procurement, in compliance with the EDL.

The norm of providing better patient care: The use of data for informing policy and practice helps impart normative legitimacy, concerning judgments about whether the technology is right for society (Suchman, 1995). The department-wise reports, in this case, received positive and welcoming feedback from the physicians, who believed they would be able to provide better care to patients as they would help them decide on which antibiotics to prescribe. A gynecologist told us:

> *I write prescriptions for almost 50 patients every day and 60-70% of these patients come with urinary tract infections (UTI) and are prescribed either second or third-line antibiotics. However, according to the report, the first-line antibiotic for UTI is also sensitive in 80% of cases in the last six months. If I have access to this report, I could prescribe first-line drugs without a second thought.*

Physicians had expressed requirements for such a report in the past but believed that such a report was not possible at a public hospital grappling with the challenges of low resources and capacities. With such a report, physicians believed they could provide better care to patients, which enhanced their sense of professional pride, strengthening the legitimacy of the digital monitoring system. A gastroenterologist while looking at the report told us:

> *This report is extremely helpful while writing prescriptions on a daily basis. I often prescribe second-line antibiotics because we assume that the first line will not work which increases the risk of resistance. This can provide information about what antibiotics can be prescribed to the patients based on current data which is updated regularly. In the future, I also want a report of only resistance from my department which will guide what antibiotics are resistant to and should not be prescribed.*

4.2.2 Building internal capacity and ownership

Inadequate focus on building internal capacity and ownership of new digital systems has been largely responsible for their lack of sustainability and the phenomenon of "pilotitis" reflecting the inability of systems to move beyond pilots (McCann, 2012). Braa et al. (2004) have emphasized the mutual interplay between interdependent processes of sustainability and scalability. In our case, this implies that without the system use being scaled across hospital departments and other hospitals, they will not sustain and

become part of institutional work. If the larger organization does not see the value of the system (scale), they will not invest in it by establishing structures, such as budgets, for the intervention to become part of institutional work (sustainability). Our case identified three key mechanisms for building this internal ownership: i) proactive and positive attitudes of the microbiologists; ii) learning by doing based capacity building approaches, and iii) the use of a flexible and easy-to-use open-source digital platform.

Microbiologists were the key coordinators at the hospital to manage the ABR data and their positive attitude toward the digital system was fundamental to building institutional work. Several factors contributed to building and evolving these positive attitudes. One was the responsiveness of the technical team during the design and ongoing implementation which helped the microbiologists to quickly see the value of digitization through steady improvements to their everyday work of AST data management, which helped raise their motivation levels. The technical team adopted a "*learning by doing" approach* for building the capacity of the microbiologists by actively encouraging them to give design inputs and involving them in testing the application, which helped them build an understanding of how the application worked. Gradually, a self-reinforcing cycle was created with the microbiologists' giving inputs, the technical team incorporating changes quickly, and the use of the improved application providing further added value. This led to more complex requirements being provided, enabling the microbiologists to do tasks they could not do earlier, such as data quality analysis. This encouraged them to make requests to the hospital management to change data recording registers and seek enforcement of regulations for the completion of the requisition forms. These were a reflection of their increased capacity and ownership of the digital systems. These processes of ownership building are already showing fruits in the building of institutional work, for example, in encouraging the management to use the AST data in building antibiotics policy, where the microbiologists will have a key role.

Another enabling factor in building local ownership was the use of a free and open-source platform (called DHIS2, see dhis2.org) for application development. This implied the hospital owned the source code, which would have not been possible if a proprietary platform had been used. The *platform capabilities* enabled the development of new functionalities without the need for programming, allowing for rapid response to the evolving informational needs of microbiologists. DHIS2 has an open metadata model and a flexible user interface that can be rapidly configured based on organization-specific requirements. This configuration can be done by "super users" without the need for skilled computing specialists. In the future, it is very possible that microbiologists could be trained to become "super users" and build capabilities to configure the application to their specific requirements. This would represent a high level of establishment of institutional work.

4.2.3 Expanding networks of stakeholders

Actor-network theory (ANT) (Callon, 1984) states that networks become more robust as they expand and take on a more heterogeneous character (Law, 1992), and translation happens when stakeholders in the network, start to speak on behalf of the network. Law (1992; p5) has argued that translation is the *transformation and the possibility of equivalence, the possibility that one thing (for example an actor) may stand for another (for instance a network)'.*

The microbiology lab can be seen as a network, situated in a larger network of the hospital with multiple departments with varying everyday practices. The digital intervention became a part of the microbiology network and could add value to routine practices. This encouraged the microbiologists to become spokespersons for the larger network, as represented by their presentations in the two annual workshops which were attended by all departments of the hospital and also members from surrounding hospitals. The network was gradually expanded and made more heterogeneous, such as by the HISP India team enrolling experts from other hospitals to support the policy development process.

Latour (1986) argued that technology has no impetus of its own and is spread in space and time by people advocating it. In this case, the expansion of the network was made possible because the microbiology team first shaped the application according to their needs, modified it by providing regular feedback to the design team, transformed it to support data analysis to provide meaningful outputs, and gradually translated it to be used by other stakeholders. The acceptance of the digital monitoring application by stakeholders in the network legitimized its use and created new forms of institutional work, for example, developing an antibiotic policy at the hospital. The process of translation allowed the technical team to streamline their efforts for the attunement of the application to fit the requirements of the microbiology lab in the nearby hospitals. One of the major learnings for the technical team was to focus on data quality issues right from the start, as it was a core pain point for the microbiologists and was the

foundation for relevant output development. A summary of the routinized practices, and their mechanisms of translation into institutional work is summarized below (Table 6):

Table 6. Institutional Work for Creating, Maintaining, and Disrupting Institutions

Routinized practices	Mechanisms to translate into institutional work	Form of institutional work
Regular monitoring of data quality for meaningful outputs	- Creating value of the data by making visible added institutional value - Building internal capacity and ownership	**(Embedding**) Adding the new practice of doing quality checks into every work **(Enabling work)** The technical team and the microbiology team working together to improve quality by preparing a monthly data quality report.
Dissemination of monthly/quarterly antibiotic susceptibility reports to clinical departments and hospital management for patient care and policy making	- Establishing legitimacy - Circulation of relevant outputs with meaningful information thereby developing a norm to provide better patient care	**(Changing normative associations)** extending existing practices to promote new work of improving the data quality by operational realignments eg: training interns; changing forms and registers, etc. **(Constructing normative networks)** bringing people together through regular discussions and workshops to discuss the issues with data dissemination and brainstorm solutions
Digitized department-wise reports being a part of the monthly AMS meeting	- Increasing recognition for the value of data - Expanding the network of stakeholders	**(Constructing normative networks)** creating and extending the network of stakeholders to normatively sanction existing practices to add them to the everyday work **(Dettering)** Authoritative measures by the management to develop the hospital antibiotic policy

4.3 Bridging the Gaps Between Formal Institutions and Informal Constraints

North (1990, p3) emphasizes the distinction between organizations and institutions, arguing that "if institutions are the rules of the game, organizations are the players". In our case, the hospital represented the organization and the different practices, the institutions. Institutions play several roles to manage the action of actors by framing the behavior of individuals in facilitating social action, structuring incentives, and helping to reduce the uncertainties associated with social interaction. Institutions consist of formal rules and informal constraints. Sautet's (2020) model of the relationship between formal and informal institutions describes the potential of organizational change or not. A closer overlap between formal and informal institutions can enable the possibility of organizational change while a large gap would impede this. This framework was applied by Piotti et al. (2006) who attributed the failure of the HIV/AIDS program in Mozambique to introduce new indicators to the high degree of the gap in the new data requirements to generate the mandated indicators (the formal institutions) and the constraints at the health facility, such as the availability of registers and high workload of the health workers (informal constraints).

Before digitization, there was limited practice and culture of ABR digital data management, and the value data brings to clinical practice and policy. Decisions to introduce the digital system represented a formal institution, which was met with multiple informal constraints such as the absence of dedicated data entry staff. This gap between the formal and informal was bridged by the HISP India team by hiring a data entry staff fully dedicated to the microbiology lab. With the introduction of the digital system, the need for the microbiologists to own and evolve the system represented a formal institution that was met with constraints of capacity because the team had limited prior experience in working with digital systems. This gap between the formal and informal was bridged by capacity-building approaches to *learning by doing* where they actively participated in system design and implementation. This also built their confidence and led to them showing increased ownership of the system. Another formal institution was represented by the need for a department-wise report to start using the data generated at the hospital. This was met with the constraints of capacity and operational challenges at the lab such as data in manual registers, illegible handwriting, and missing fields. The report was also complex and time-taking to design. This gap was bridged through close collaboration between the microbiology team providing the design inputs and the

technical team translating these inputs into usable functionalities building upon participatory prototyping approaches.

4.4   Proposed Theoretical Framework

As seen through the case analysis, the continued conduct of various practices (Orlikowski, 2000), their routinization, and translation into institutional work represent a process that unfolds over time. Drawing upon the analysis of the practices based on the concepts from instutional theory, we develop a theoretical framework to guide the routinization and institutionalization of the digital monitoring system. This is schematically presented in Figure 5 below.
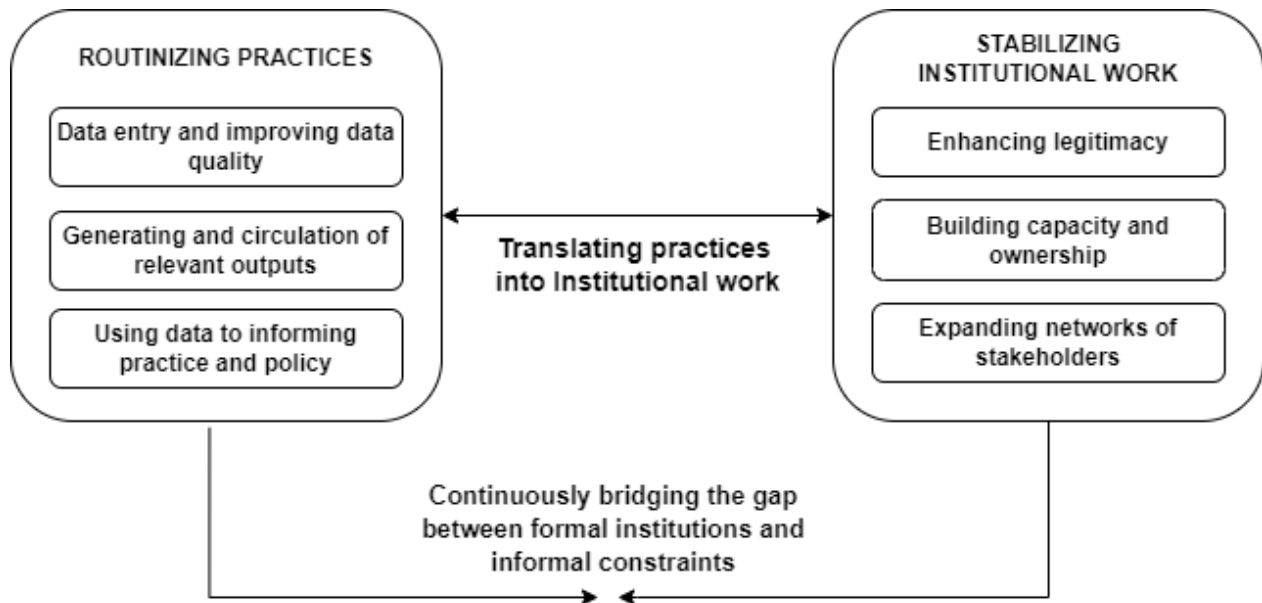
Figure 5. Framework for Stabilizing Institutional Work

5   Conclusions

This paper contributes by developing an analytical framework to study the process of routinizing information practices and their stabilization as institutional work. A unique aspect in the development of this framework is by combining concepts of systems requirement and implementation from IS research, with notions from institutional theory, such as institutional work. Such an approach helps bring richness to IS concepts through their stronger contextualization within organizational settings. Arguably, such an approach represents a novel way to engage with the critical problem of ABR invisibility, particularly within the context of public health systems in LMICs. We have in this process tried to highlight how IS research can make a meaningful contribution to an important but neglected area of research and practice.

While our framework has been formulated in the specific context of ABR reporting within the setting of a resource-constrained setting of the public health system in India, we argue the findings also have implications for ICT4D and broader IS research. Digital interventions always come with new practices, which need to engage with what exists, and they need to be stabilized into institutional work for time. Without such processes of routinization and translation into institutional work, digital interventions will not provide adequate value to sustain and scale over time. Our proposed framework provides some suggestions on how such value can be better achieved.

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Appendix

List of Abbreviations:

ABR – Antimicrobial Resistance
AST – Antibiotic susceptibility test
LMICs – Low- & middle-income countries
SDGs – Sustainable development goals
NAP – National Action Plan
OPD – Outpatient Department
IPD – Inpatient Department
ED – Emergency Department
ICU – Intensive care Unit
CLSI - Clinical and Laboratory Standards Institute
DEO – Data Entry Operator
MS – Medical Superintendent
HOD – Head of the Department
JR – Junior Resident
SR – Senior Resident
R-I-S – Resistant, Intermediate & Susceptible
HISP – Health information systems programme

List of Figures

Figure 1. Requisition form received at the lab with each sample

Figure 2. A dummy screenshot of the data entry application

Figure 3: RIS in the data entry application
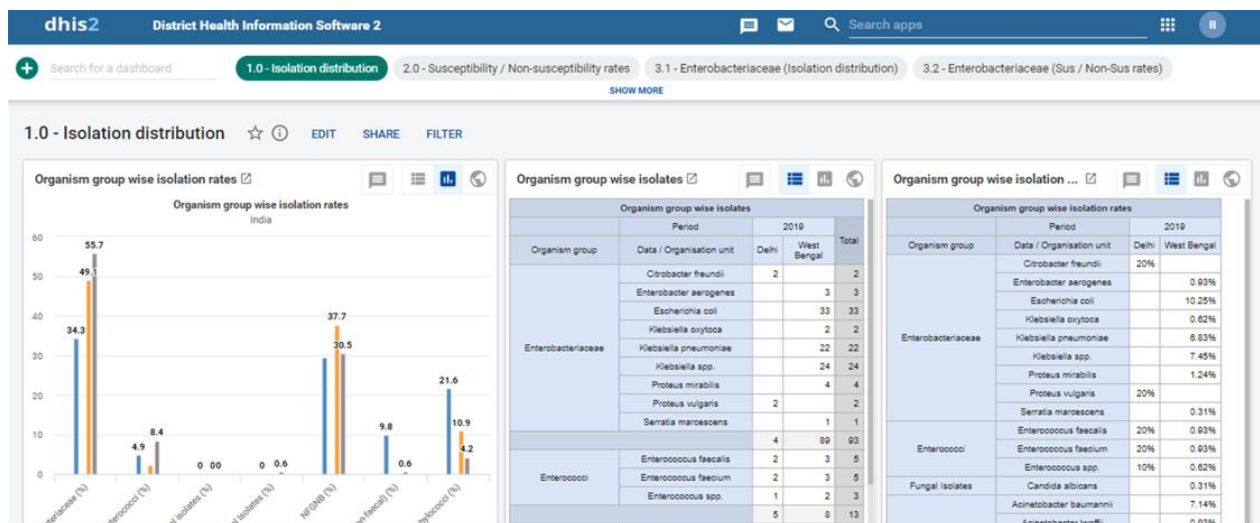
Figure 5. A dummy dashboard and department-wise report
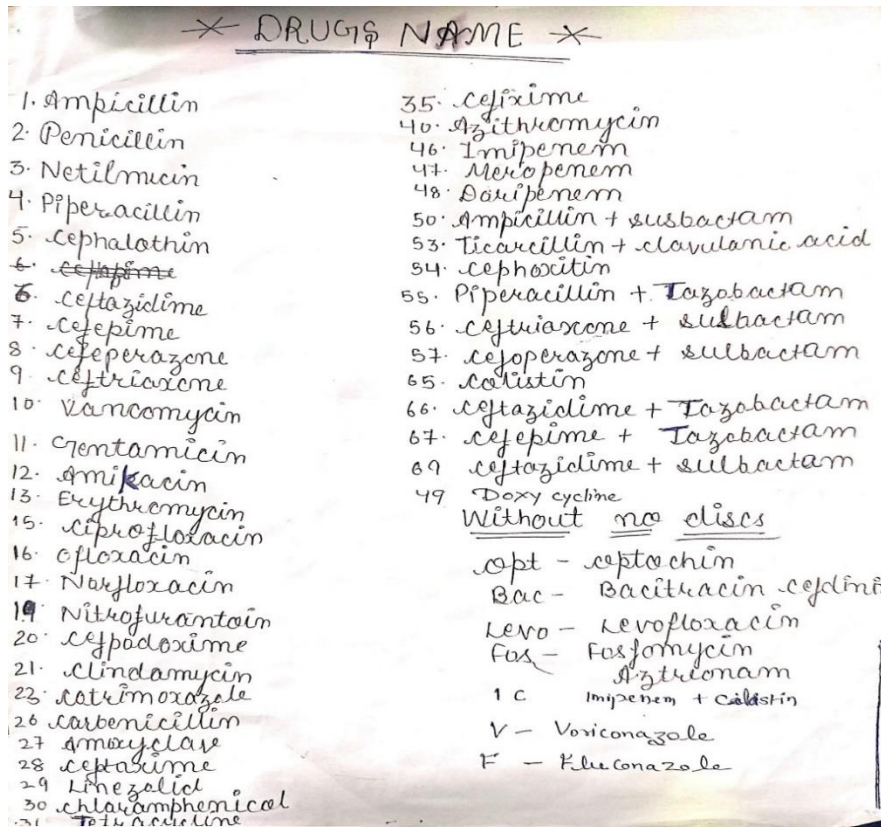
Figure 5. Antibiotics codes prepared and pasted on wall for the data entry operator

Figure 6. Register for data entry at the microbiology lab

Figure 7. The letter sent to the MS by the microbiology team

Figure 8. Format for the new requisition form

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