RESEARCH ARTICLE

Uncovering generative mechanisms of information use for project monitoring in humanitarian health management information systems

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Abstract

Humanitarian medical organizations rely on information on and from the ground to evaluate their effectiveness and accountability. Related digitalization efforts within health information systems assume an instrumental rationality in the use of data. However, previous research identified a multitude of factors influencing actual information use for evidence-based decision-making for healthcare delivery. This case study, anchored by critical realism philosophy, unpacks these nuances against the backdrop of a globally operating organization (Médecins Sans Frontières). It aims to highlight the contextual conditions and structures that enact the contingent mechanisms at work in project monitoring within humanitarian health management information systems. By applying an affordance-based causal analysis, three mechanisms are identified: first, an analytics service provides templated analysis modalities resulting in user–producer–provider relationships; second, the rationalization and synchronization of content and software artifacts gives rise to the standardization strategy of flexible generification; third, the study uncovers the potential for increased internal social discourse and advocacy through collaborative and mobile data analysis. This paper proposes that mechanism-based explanations can be useful for theory-building in information systems research as well as for providing insights to practitioners in the humanitarian health sector.

KEYWORDS
critical realism, health management information systems, humanitarian organizations

Armed conflicts, epidemics, natural disasters and other humanitarian crises are inherently complex, protracted situations that lead to large numbers of refugees, internally displaced and entrapped persons. In these situations, humanitarian short-term emergency responses often evolve into long-term interventions (Spiegel, 2017; Vila-Pozo & Sahay, 2018). Organizations providing aid in these complex contexts are expected to demonstrate their effectiveness and accountability to the donors and the recipients of aid. The organization's information system (IS) is a critical tool in fulfilling this demand (Lewis & Madon, 2004; Read et al., 2016), as information and communication technologies (ICTs), when embedded in a broader view of technological, social and institutional innovations, are considered a catalyst for improved health outcomes (Walsham, 2020).

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However, a 2018 review of a sector-wide network of humanitarian organizations concluded that despite efforts of information collection for impact and outcome monitoring, as well as the attempts to design more adaptable and context-specific programs, substantial improvements have not yet occurred (Active Learning Network for Accountability and Performance [ALNAP], 2018). Reasons include the complex settings in which health technologies are deployed and disseminated (Mesmar et al., 2016), which are characterized by factors such as intermittent or expensive connectivity, unsafe environments and the need to handle highly sensitive data.

The central role of ICTs as a decision-making tool in humanitarian aid is relatively new. An ongoing paradigm shift is suggested to be taking place in international development towards a "digital nervous system" permeating most development organizations: "the iconic technology is now the digital platform, the key goals are the SDGs [the United Nations' Sustainable Development Goals], and the key issue is now impact alone." (Heeks, 2020). Humanitarian actors, such as non-governmental organizations (NGOs) increasingly use information from health management information systems (HMIS) for their reporting (Braa & Sahay, 2017). HMIS store routinely collected and aggregated healthcare data and indicators (Dixon & Grannis, 2020), which are employed as surveillance or monitoring systems in order to guide interventions in real time (Mesmar et al., 2016).

Previous research on HMIS has identified various interconnected organizational, technical and behavioral factors that play a role in the use of information for evidence-based decision-making, such as data quality and availability, individual capabilities and governance (Aqil et al., 2009; Nutley & Reynolds, 2013). Individual data literacy as well as the "information culture" of organizations are supporting or determinant factors for effective decision-making (Aqil et al., 2009; Kumar et al., 2018; Penn & Dent, 2016). Vila-Pozo and Sahay (2019) identified three elements of decision-making by humanitarian medical organizations using data for project monitoring and surveillance: (a) operationability (use data to follow-up trends and identify alerts for constant response and adaptation of activities); (b) accountability (use data to be accountable for day-to-day activities and operational decisions); and (c) contextuability (use data to know and analyze the context when you are new to the situation). However, factors related to system design such as user involvement, work flow or human–computer interaction are in general still underexplored (Kumar et al., 2018). This study aims to contribute to this research area by elaborating on the structures and conditions of information use mediated through humanitarian health management information systems (HHMIS) within the context of project monitoring.

The study is therefore guided by the following research question: *which generative mechanisms contingently lead to effective use of information for project monitoring in international humanitarian medical organizations?*

It draws on literature from ICT4D (information and communication technology for development) and health information systems (HIS) disciplines as well as on the philosophy of critical realism to describe the contingent conditions and structures of mechanisms related to information use in a case study of the HHMIS of a globally active non-governmental organization.

This paper provides insights for humanitarian health practitioners involved with digitalization initiatives as well as a theoretical contribution to the methodological practices of the critical realist philosophy underpinning this study. It proceeds by providing the philosophical and theoretical foundations in the research methodology section, followed by descriptions of the method, setting and case. The identified mechanisms are presented in the findings section, followed by the discussion, practical implications and conclusions.

1 | RESEARCH METHODOLOGY

The multitude of identified factors of information use in health information systems precludes the isolation of one phenomenon in a controlled study, as a force outside of the constrained environment can be a non-negligible influence on the phenomenon under consideration. In an open system, we must assume a dynamic and variable reality that is influenced by technological, social, organizational and environmental factors, and it is necessary to analyze the causality of a certain phenomenon—information use—in order to improve it for increased effectiveness.

1.1 | Critical realism

Critical realism (CR) has emerged as a new (by philosophical standards) and legitimate alternative to positivist and interpretive approaches to IS research in the past two decades (Mingers et al., 2013; Tsang, 2014; Wynn & Williams, 2012, 2020). Initially, the philosophy of CR was formulated by the British philosopher Roy Bhaskar in the 1970s (Bhaskar, 2008) and extended by Bhaskar himself as well as Sayer (2010) and others in the 1990s. As a philosophy of science, it includes specifications about its ontology (assumptions about the existence of the world and society) and its epistemology (the study of how knowledge is possible).

Even though there is no unifying framework, three core assumptions underlie the philosophy. Ontological realism argues that reality is independent of our perception and knowledge. Epistemic relativism states that our knowledge of this world is limited, fallible and contextual. Judgemental rationality refers to the commitment to the rational evaluation of the diverse and sometimes conflicting theories about the world. This rationality is (a) enabled by independent reality, and (b) necessitated by the relativity of our knowledge: if reality is intransitive and

independent, and we only have fallible theories in our own transitive reality, there must be a rational judgment on the plurality of assertions of this world for science to be possible.

Adhering to these principles, a stratification of reality in three nested domains is specified (visualized in Figure 1). The real consists of physical and social structures (such as organizations, norms, cultures) and mechanisms, which may (or may not) generate events in the second domain (of the actual), which states what must have occurred even though it might not be (possible to be) empirically perceived. In the third domain (the empirical), these events may be observed or experienced. In that sense, structures have the potential to enable or constrain events through generative mechanisms which are "nothing other than the ways of acting of things" (Bhaskar, 2008) (the definition of a CR-based mechanism has been repeatedly refined, see Wynn and Williams (2020)). The intransitive dimension of a reality consisting of structures, mechanisms and processes exists independently from our knowledge in the transitive dimension. CR states that knowledge of the world is emergent, political and imperfect; Bhaskar termed the mix of these two the "epistemic fallacy," the essential mistake of reducing the ontological domain of existence to the epistemological domain of knowledge, so that statements about our existence are constructed or modulated by our knowledge of being (Mingers et al., 2013). What follows is that critical realist researchers do not have immediate access to the intransitive dimension, but that they reason about reality (the structure and mechanisms) through abstract causal analysis of concrete events generated by mechanisms in order to create knowledge within the transitive dimension. "Concrete research studies actual events and objects as 'unities of diverse determinations', each of which has been isolated and examined through abstract research" (Sayer, 2010).

Empirical or actual events can be created or canceled by a single or multiple mechanisms, and structures can generate one or multiple mechanisms. These descriptions of dependencies and emergence are visualized in Figure 2.

The main two reasoning methods for causal analysis are retroduction (identifying new mechanisms based on the metaphorical application of prior knowledge) and retrodiction or abduction (the application of existing theory or known mechanisms to explain different phenomena) (Wynn & Williams, 2012). Mechanisms do not imply a linear causality that produce the same outcome every time it is generated. Instead, mechanisms are contextual and dependent on other mechanisms.

As an IS-related discipline, ICT4D is suitable for CR-based research approaches (cf. Buchana et al., 2018; Gebre-Mariam & Bygstad, 2019; Njihia & Merali, 2013; Thapa & Omland, 2018). More broadly, critical research has been used in various ICT4D studies as well (De' et al., 2018; Poveda & Roberts, 2018; Singh et al., 2018). CR-based ICT4D research makes use of an "iterative, pluralist and reflexive methodology with emancipatory values" (Heeks & Wall, 2017). It forces an involvement with the ICT4D context based on what exists—local expertise, needs and adaptive capabilities—and how it evolved over time, rather than perceiving development as what is lacking (Njihia & Merali, 2013). Identified generative mechanisms can further be tested and used in action research (Bygstad et al., 2016) as a basis for strengthening the exchange between theory and practice, a direction that is in need of further examination in critical ICT4D research (Bon & Akkermans, 2019).

FIGURE 1 Stratification of reality in critical realism (adapted from Bhaskar, 2008)
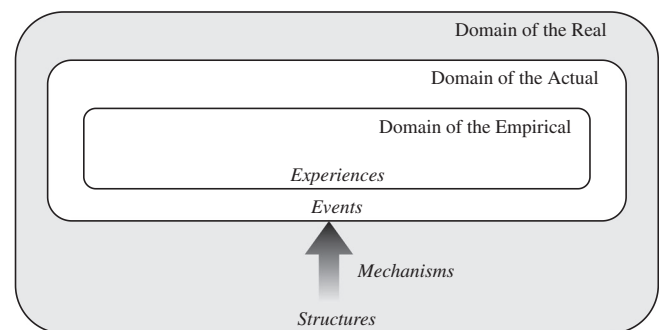
FIGURE 2 Structures, mechanisms, events (adapted from Sayer, 2010, Figure 8)
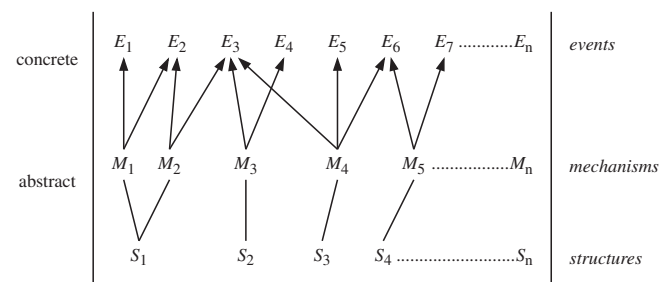
1.2 | Affordance theory

In order to identify generative mechanisms, it is required to identify potential and actual capabilities of entities, a task that invites the introduction of the concept of affordances. An affordance is an "action possibility available in the environment" independent of individuals' ability to recognize them. The term has its origin in ecological psychology (Gibson, 1979). IS scholars adopted affordances as a lens for the study of the limits and possibilities of relationships between actors and technologies because they do not determine how actors use a technology while still limiting the number of potential uses (Stendal et al., 2016). At the same time, "there is no one way to adopt the affordance lens" in IS research; however, affordances commonly contain "objects with properties," "actors with goals," "action possibilities" and "actor capabilities" (Stendal et al., 2016). This study adopts the stance of potential affordances as categorized by Lanamäki et al. (2016) and thus considers affordances as "the potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an object (e.g., an IT artefact) and a goal-oriented actor or actors" (Volkoff & Strong, 2013) because IT artifacts—in this case a HMIS—are flexible by nature (Bygstad et al., 2016; Leonardi, 2011; Nicholson et al., 2019), and their related organizational change processes not predetermined (Orlikowski, 1996). The notion of affordances as a tool for unpacking the interdependency of human agency and material structures of IT artifacts that is neither technologically nor socially deterministic (Leonardi, 2011; Volkoff & Strong, 2013) can be mapped to the CR-based domain of the real.

Additionally, the lack of specific inclusion of technological artifacts in CR-based IS research requires a more ICT-specific integration as affordances can link specific IS and ICT directly to actors and, in doing so, describe their inherent capabilities and limitations (Bygstad et al., 2016). As potentialities of action related to IT artifacts are methodologically easier identified than whole mechanisms, affordances here are regarded as building blocks of mechanisms (Volkoff & Strong, 2013; Wynn & Williams, 2020). The specificity of the potential of action tied to a methodological guidance mapping actors to ICT is absent in other CR-based methodologies such as found in Thapa and Omland (2018) or Wynn and Williams (2012).

Thus, legitimate and practical value is seen in adopting the affordance-based theoretical foundation that guides the research method of this study.

2 | RESEARCH METHOD AND SETTING

To answer the research question, the research approach presents an in-depth case study of the digitalization efforts to establish a web-based online platform for monitoring and surveillance in three sub-organizations (Operational Centers, or OCs) of an international humanitarian medical organization. The unit of analysis are practitioners of digital health within the organization, namely managers, advisors, users and researchers of the platform in order to gather a wide array of viewpoints. A case study was chosen as it is "an empirical inquiry that investigates a contemporary phenomenon within its real life context when the boundaries are not clearly evident and in which multiple sources of evidence are used" (Yin, 2018). Critical realism is well suited to conduct case studies (Tsang, 2014; Wynn & Williams, 2012) and thus a fitting method for addressing the research question.

2.1 | Data collection

Data collection was conducted iteratively and involved five semi-structured interviews with six interviewees. Table 1 lists the details of the interviews. The first interview was conducted with two participants to get a broader initial picture of the organization. The number of interviews was determined by the evidence saturation (Glaser & Strauss, 1967) of the affordances and mechanisms theorized. The semi-structured format of the interviews was chosen due to having an initial frame of reference pertinent to the research question that still allowed new ideas to emerge. The participants were identified with the help of a purposive sampling strategy based on their involvement with the organization's HIS.

TABLE 1 Interviewees and interview duration

Name	Position	OC	Duration
Interviewee 1 (INT1)	Program manager	1	50 min
Interviewee 2 (INT2)	eHealth epidemiologist	1	
Interviewee 3 (INT3)	Humanitarian HIS researcher	2	70 min
Interviewee 4 (INT4)	Medical officer	1	45 min
Interviewee 5 (INT5)	eHealth epidemiologist	2	50 min
Interviewee 6 (INT6)	HIS medical content advisor	3	55 min

The audio and video interviews were conducted remotely between June and August 2020 using online call software such as Skype and WhatsApp. Video conference interviews offered a viable method of data collection based on the criteria identified by Farooq and de Villiers (2017): researchers as well as interviewees were already familiar with using call software in their day-to-day work, and it was not critical to understand all contextual factors in order to answer the research question. The COVID-19 pandemic further prescribed remote communications and limited the availability of medical personnel.

The interview protocols were iteratively adapted for each new interview. The related interview guide, which provided the starting point for the interviews, is attached in the Appendix A. The questions always revolved around the following themes:

- The use of information or provision of the enabling platform features.
- Challenges and benefits compared to earlier monitoring or digitalization approaches.
- Opinions about statements from earlier interviewees or relevant literature.
- Impact of structural and environmental issues in international development (e.g. Logframe, Internet connectivity) on their daily work.

In order to further strengthen the findings through data triangulation, documents specific to the OCs were reviewed from the years 2017–2019, including medical activity reports, annual reports and financial reports, as they provided official statements about the organization's digitalization strategy. Additionally, empirical research published in the literature about the same organization's IS such as from Vila-Pozo and Sahay (2018, 2019) as well as from field research (Médecins Sans Frontières, n.d.-a) were included in order to broaden the research-based perspective. Lastly, HMIS (District Health Information Software 2) documentation has been included to confirm that the reported functionality is indeed available.

The research adhered to the Netherlands Code of Conduct for Research Integrity. The participation of the subject matter experts in the study was voluntary. Before each interview, informed consent was gathered in order to ensure permission for the recording of the interview. Each participant's associated OC has been anonymized (see Table 1) to protect the identity of the interviewees. Appropriate protection measures were implemented for the storage of data such as encrypted hard drives and password-protected folders.
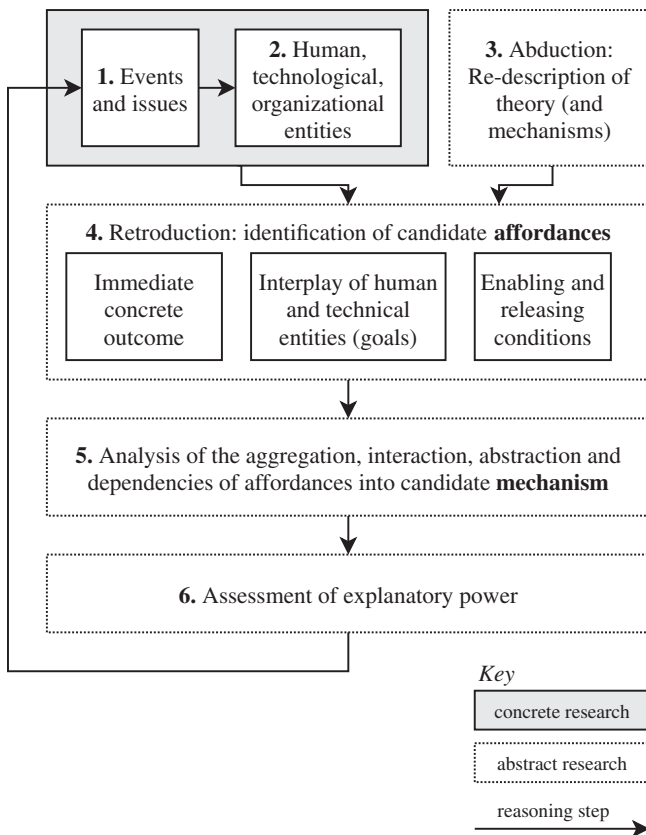
2.2 | Data analysis framework

On the basis of affordances embedded in a critical realism underpinning, the framework of Bygstad et al. (2016) for critical realist data analysis fits well because it provides methodological guidance to construct and subsequently test mechanisms. Its strength lies in its pragmatism in reasoning about causality in IS by mediating and constructing the abstract CR concepts with more tangible affordances. The structure of the framework is outlined below as well as depicted in Figure 3.

- Description of events and issues (clusters of observations in the domain of the real).
- Identification of key entities of the case (such as human actors, IT artifacts, organizational units).
- Abduction (identification of relevant theory or mechanisms re-contextualized in the case study).
- Retroduction (identification of candidate affordances).
- Identification of immediate concrete outcomes (high- or low-level but directly achieved through the use of technology and the realization of the goal of actors).
- Analysis of the interplay of human and technical entities (such as users and IT artifacts).
- Identification of enabling and releasing conditions (whether affordances are actualized depends on contextual conditions that stimulate or release the outcome).
- Analysis of the set of affordances (identifying aggregations, groupings, dependencies or abstractions).
- Assessment of explanatory power (related to the events observed in step 1) and further data triangulation.

The described steps inform how the collected data is coded. Since CR aims at explaining experienced phenomena through causal chains—from the concrete to the abstract—this research needs to work backwards from experienced results (events and issues) towards the affordances in order to build mechanisms grounded in the data. Thus, an abductive variation of grounded theory allows the researcher to approach the research without inhibitions (open coding) but still draw upon existing theory and mechanisms via abductive reasoning and axial coding true to the principles of CR (Hoddy, 2019).

After the transcription of the interviews and review of documents, the data was descriptively open-coded with the qualitative data analysis software ATLAS.ti in multiple iterations. Events and issues were extracted including the human and technical entities, such as IT artifacts, sub-organizations, teams and stakeholders of the events and issues. In the second cycle, the codes were grouped into the following framework-specific categories:

FIGURE 3 Framework for critical realist data analysis (developed from Bygstad et al. (2016))
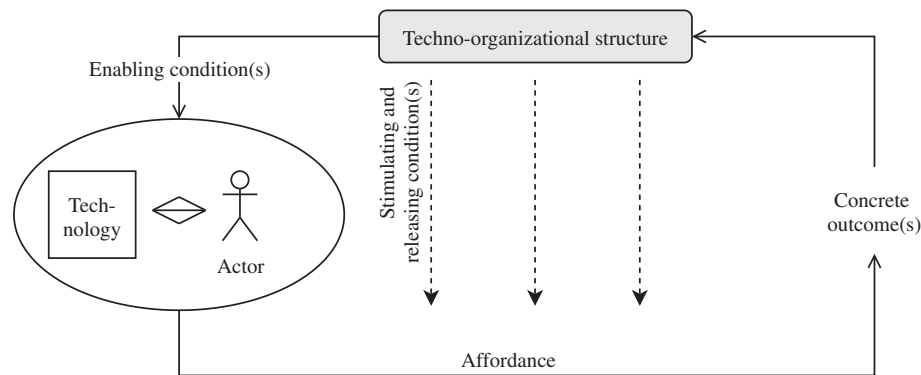
FIGURE 4 Affordance viewpoint (adapted from Bygstad et al., 2016, Figure 2)

- Immediate concrete outcomes.
- Actor's goals for the platform.
- Enabling or releasing conditions.

Starting from the most-occurring codes in each group, these categories were used to iteratively sketch affordances through the mapping of conditions, structures and low- and high-level outcomes. The process of retroduction from case data is intended to be highly creative (Tsang, 2014; Wynn & Williams, 2012, 2020). Additionally, the network of conditions, affordances and outcomes was mapped to identify shared conditions and outcomes of affordances and enhanced with relevant and applicable IS theory and previously identified mechanisms (abduction). The affordance emerges from the relation of technology and actor that leads to a concrete outcome under enabling, stimulating and/or releasing conditions, which subsequently can alter the structure from which it emerged (Bygstad et al., 2016). The affordance model is illustrated in Figure 4.

Finally, mechanisms were invented by analyzing dependencies between affordances, grouping affordances, mapping to existing mechanisms and abstracting into higher-level mechanisms (Bygstad et al., 2016), before their explanatory power was assessed against the empirical evidence

(Bygstad et al., 2016; Sayer, 2010). An example of the process leading from data to affordances to the mechanism can be found in the Appendix B.

3 | CASE DESCRIPTION

3.1 | Médecins Sans Frontières

This paper examines the case of the project monitoring digitalization efforts of three Operational Centers (OC) of Médecins Sans Frontières (MSF), a global humanitarian medical NGO. MSF is a large, relatively independent organization with a solid history and proven track-record in humanitarian projects. MSF provides emergency medical assistance to people affected by natural or man-made disasters, irrespective of race, religion, creed or political convictions (Médecins Sans Frontières, n.d.-b). MSF concentrates primarily on healthcare—as one of the last few international humanitarian agencies it does not rely on a "cumbersome coordination system that prioritizes process over outcome," which increases their response effectiveness (Spiegel, 2017). The overall organization has an associative structure of five OCs where operational decisions are made relatively independently. MSF operates in various countries where projects are coordinated through in-country coordination offices. The OCs report to the international council and international office, and there are various cross-OC teams for specific medical or organizational topics.

The following OCs were included in this study: Amsterdam (OCA), Barcelona-Athens (OCBA) and Brussels (OCB). Due to the independence of OCs, the types and related onsets of digitalization processes vary, but the common theme for all has been a gradual shift from using spreadsheet software on a per-project basis towards a web-based integrated health information system for the medical-operational monitoring (or surveillance) of projects. The distinct and shared processes and events are displayed as a timeline in Table 2.

3.2 | DHIS2

All OCs of MSF have transitioned towards using District Health Information System 2 (DHIS2) for their HMIS for project monitoring and surveillance. DHIS2 is an open source, web-based HMIS platform in use by 67 low and middle-income countries (LMIC) as well as many non-profit, non-governmental and multi-national organizations. Approximately 2.3 billion people are covered by DHIS2 (Nicholson et al., 2019). Core development and governance is carried out by the global Health Information Systems Program (HISP), a "network of North-South-South collaboration." The University of Oslo is a key factor in the coordination of the program (Nicholson et al., 2019).

DHIS2 is part of a promising foundation for HMIS in LMIC to achieve the Sustainable Development Goals, and DHIS2 "should become the primary source of quality data for resource allocation and impact measurement" in the public health domain (Farnham et al., 2020). Still, concerns and issues remain: data is primarily collected in health facilities by overworked healthcare workers and later manually tallied and entered, which introduces delays and errors. These facility-level workers are not aware of the purpose of the collected data within the information life cycle. Facility-level capacity building is often inadequate or non-existent, wide-ranging data quality issues are prevalent and Internet connectivity challenges persist (Farnham et al., 2020).

However, the flexibility and adaptability of the platform and related metadata model enables NGOs, such as MSF, to implement the software as their own HMIS and, if necessary, to extend functionality through platform apps compatible with the open software architecture (Nicholson et al., 2019). Thus, an organization can participate to some extent in the development of a horizontal approach or "bottom-up empowerment" (Walsham, 2020). Since the Ministries of Health in countries where MSF operates often also use DHIS2 as their national HMIS, synergies are

TABLE 2 Timeline of key events recorded

ID	Event	Operational center	2015	2016	2017	2018	2019	2020
E1	Excel as main tool for data collection	OCA, OCB, OCBA	x	x				
E2	Creation of eHealth units, formulated goals of integrated HIS for monitoring	OCA, OCB	x	x				
E3	Piloting and scale-up of DHIS2 and legacy data migration	OCA, OCB, OCBA		x	x	x		
E4	Partial adoption of data and metadata synchronization	OCBA, OCA, OCB			x	x	x	
E5	Partial adoption of integrated reporting app	OCA					x	x
E6	Increase in directly-online projects	OCBA						x
E7	Processes of downsizing and rationalization of metadata	OCBA, OCA						x
E8	Integration processes of non-standard projects	OCBA						x

possible, for example, in data sharing, data integration efforts or capacity building. However, as ministries often do not have the necessary skills and resources to completely take ownership of a new system or a subsequent data integration, they rely on the expertise of intermediaries such as the NGO, thereby maintaining or exacerbating the dependency on external technical assistance to adapt the generic tool of DHIS2 to their own specific and changing needs (Nicholson et al., 2019). To alleviate this, initiatives that build capacity are necessary, for example through data-use workshops. These "collaborative peer reviews of practice" have proven to be effective to improve the link between data quality and information use in national HMIS (Braa et al., 2012).

4 | FINDINGS

Three mechanisms were identified in relation to the organization's HHMIS-driven project monitoring: templated analytics service; standardization; and collaborative and mobile capabilities.

All affordances have structures of a human, social and technical nature (the techno-organizational structure, see Bygstad et al. (2016)) that were laid out in the introduction, background and case description and make for the context in which the affordances emerge. The technology is the HHMIS platform (DHIS2).

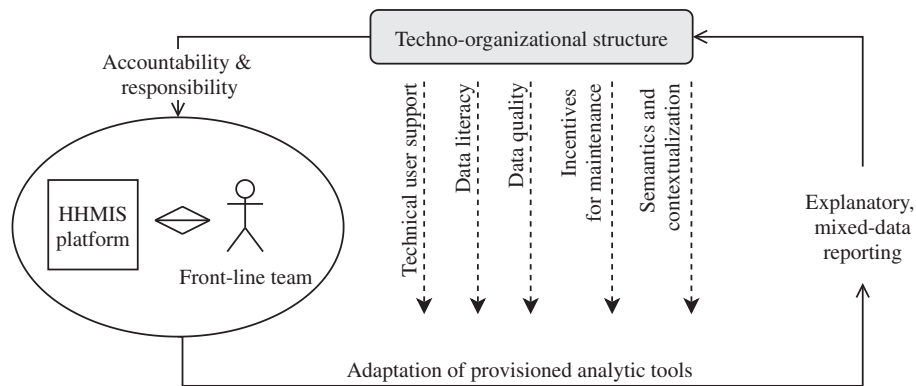### 4.1 | The templated analytics service mechanism

The first affordance that contributes to the mechanism is visualized in Figure 5 and describes the provision of templated dashboards and reporting tools. The logic of the analysis framework applied to this mechanism is listed in a tabular format in the Appendix B. The enabling conditions identified are the generally recognized time constraints on humanitarian front-line staff coupled with the feature space (available functionality) of the HHMIS. The eHealth team, usually based in headquarter offices with specialized digital health expertise, provides the front-line teams with templated HHMIS dashboards containing user-adaptive items, as well as with access to user-adaptive reporting tools. A dashboard is a collection of key performance indicators for a given thematic area, containing dashboard items of analytical objects (data visualizations, such as charts or maps, and data tables, such as pivot tables) (Chrysantina & Sæbø, 2019). The conditions for the actualization of this affordance are that the items contained in these dashboards are configured based on the current user's associated or preferred location (the where-dimension or the "user-orgunit"), which enables an adaptive user interface. One participant (INT3) stated: "they need predefined objects, like a predefined dashboard, a predefined chart, then they would use it." The affordance is also stimulated via a relatively strict naming convention (a generally agreed scheme for naming metadata entities) to manage metadata in the HHMIS. The dashboard as a whole and the assembled dashboard items can only be provided effectively when their design quality is high, which depends on the data literacy of the designer (Chrysantina & Sæbø, 2019). These objects are then distributed as part of the configuration package by downstream synchronization (see affordance in the section of the standardization mechanism).

The concrete outcome is that front-line teams have access to consistent dashboards containing descriptive analytics for operational decision-making and related reporting tools. Standardized dashboard packages provide a level of consistency (Chrysantina & Sæbø, 2019). Descriptive analytics "describe or summarize datasets making them interpretable to researchers. They allow to learn from historical events or behaviors, and understand how these may influence future events or outcomes" (Kasthurirathne et al., 2020). Descriptive analytics require more human effort to reach a decision as compared to predictive analytics, which provide estimates on the probability of future outcomes (Kasthurirathne et al., 2020).
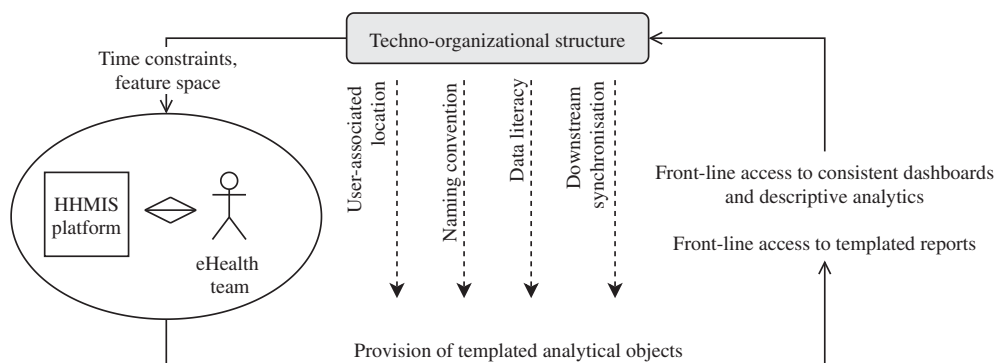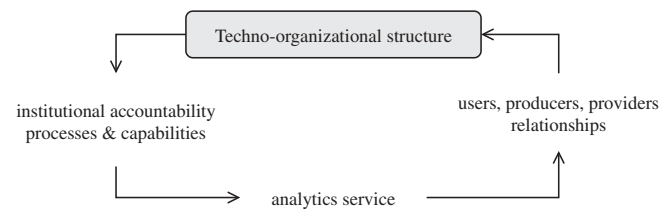

FIGURE 5   Templated analytical object provision affordance (adapted from Bygstad et al., 2016)

FIGURE 6 Adaptation of provisioned analytic tools affordance (adapted from Bygstad et al., 2016)

FIGURE 7 Analytics service mechanism (adapted from Bygstad et al., 2016)

The affordance described here provides the most common analytical approach but requires user guidance. One participant (INT2) stated: "what we trial for most [projects] is to build the dashboard that is in line in how we should use the data ... because the dashboard will be like a guidance in how you should look into your data."

The second affordance, depicted in Figure 6, shows how the front-line team accesses these analytical objects. The enabling condition is the shared understanding of the responsibility to access the platform in order to monitor the relevant indicators and the accountability of their work by backing up decisions with HHMIS-based evidence. The intrinsic value of data and data systems is generally recognized (Operational Center Brussels, 2017; Vila-Pozo & Sahay, 2019). A stimulating condition is the ability of the front-line team to easily reach out for user support in case of technical challenges. Other identified stimulating conditions are data literacy (Chrysantina & Sæbø, 2019) and the data quality of analytical objects. Another factor is an incentive for maintaining the dashboard and its items, as their configurations need to be updated to be useful in changing contexts and requirements. This can be quite a challenge if analyzing data is already demanding—one interviewee (INT4) stated: "if you are the front-line doctor or medical person, you don't really have time to do all the analysis of the data, you are really concerned with treating the patient." This incentive is supported by intuitive user interfaces that work for less technical staff. User-designed dashboards commonly have context problems where (a) no comprehensive or useful message can be drawn from them, (b) dashboard items are not linked, (c) descriptions are missing, or (d) items are not aligned with the purpose of the dashboard (Chrysantina & Sæbø, 2019). These conditions also hold true for a specific example of one OC: they developed a platform app that allowed for document-based, templated reporting of qualitative data (a narrative as found in the project situational report or "sitrep") with quantitative data (target-based analytical objects exported from the HHMIS) based on the afore-mentioned naming conventions. Sitreps are commonly used to disseminate information to and from relief workers in the field. They are intended for a cosmopolitan audience of humanitarian actors and are painstakingly produced on the ground (Finn & Oreglia, 2016). In the highly dynamic environment of humanitarian work, qualitative data is then used to give context and to justify and explain the quantitative data to a diverse set of recipients. One interviewee (INT5) stated: "the people [that are not here] just can see the indicators and numbers, but sometimes the numbers are meaningless if you don't put any context behind." However, here context means "the needs of the local population and the response of local governments and the humanitarian actors plus the gap of unmet needs" (Finn & Oreglia, 2016). The outcome of this affordance is explanatory mixed-data reporting, for example through sitreps, which act as the basis for discussion and evidence-based justifications of "their" data with higher levels. Often, the individual medical records are never transmitted due to data protection regulations.

The major challenge of the interplay between the actualizations of these affordances' is the contradiction between one of the enabling conditions (time constraints of front-line staff) and a stimulating condition (incentives for the required maintenance of the dashboard and items). Through abstraction of these two affordances, this mechanism is based on the institutional accountability processes and capabilities emerging from the structure. They serve as the basis for the analytics service provision and result in specific roles with regards to data collection, use and service provision. Front-line staff routinely aggregate, tally and enter manually, as well as they use the dashboard for the day-to-day monitoring

of their project-specific data. Thus they are data producers and users and analytical service users. The "higher-level" staff in coordination offices or headquarters who access aggregated data of multiple projects are data users. The eHealth team acts as an intermediary, the providers of the analytical service, but are neither data users nor producers. This mechanism is visualized in Figure 7.

4.2 | The standardization mechanism

The mechanism is based on two affordances. The first affordance, visualized in Figure 8, relates to rationalization via the backtracking of metadata, resulting in quantified usage and leaner IS content. The enabling condition is an initiative based on a shared understanding that too many data points were collected, which then were not used in reports. The affordance was stimulated by existing naming conventions in concert with management buy-in, which improved the ability of the eHealth team to institutionally access all relevant reports together with topic experts. This affordance led to a quantified usage of data collection, which reported how much of the actual data collected is eventually used (in reports), leading to a leaner content within the HHMIS and reducing the burden of collecting data for front-line project teams. This is beneficial. If resources invested in the information-gathering capabilities of humanitarian actors outweigh the capacity to deal with the information, it indicates an inefficiency. In such a case, a simplification exercise can be a factor in increasing efficiency (Read et al., 2016). An approach to the question whether analysis possibilities are already saturated with existing data might provide another promising tool for increasing efficiency and effectiveness. Finally, a means to highlight the history and origins of data (often termed data provenance or data lineage) can increase ownership, as one participant (INT6) stated: "When I was a doctor [at the organization] and collected so much data, that was also a part of the role including all the clinical management. What I did miss out on was: where is this data going and what's happening to my project, how am I contributing." Furthermore, data provenance can establish data origin, the chain of custody and reproducibility and automate data integrity checks (Perakslis, 2018).

The second affordance is depicted in Figure 9. It relates to an existing feature within the HHMIS platform that addresses the problem of intermittent Internet connectivity. The platform has the ability to link partly offline servers in the countries of operation to a central online instance, which is managed, for example, at headquarters. The locally deployed servers (a) update their HHMIS configuration from the central online instance, and (b) regularly upload collected data conforming to that configuration upstream to the central instance as soon as Internet
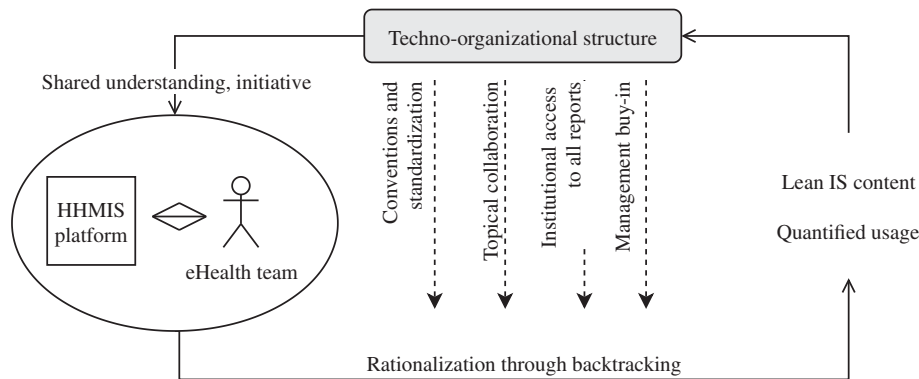
FIGURE 8 Rationalization affordance (adapted from Bygstad et al., 2016)
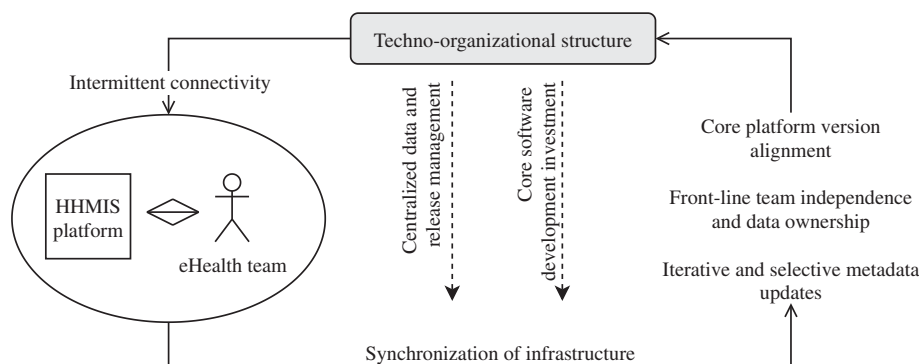
FIGURE 9 Synchronization affordance (adapted from Bygstad et al., 2016)

connectivity is available. This functionality has been documented before (Vila-Pozo & Sahay, 2018, 2019). Two conditions were identified for this affordance: centralized (configuration) data management is a prerequisite including release and deployment management. An additional condition was that software development investments into the HMIS core software were made by MSF to make it more robust and improve offline functionality (Vila-Pozo & Sahay, 2018), a feature selected to be generic and relevant across countries and use cases to be included for all users of the software (Nicholson et al., 2019). At least a minimal level of Internet connectivity is required, which is not available in every project. The outcomes indicated that more iterative and selective configurations of the healthcare service monitoring were made possible, as teams do not need to wait for yearly updates to the metadata. It also led to increased front-line team independence and data ownership (Vila-Pozo & Sahay, 2019). The benefits of this implementation did not go unnoticed across other OCs. The implementation led to, and is led by, an alignment of resources between the OCs related to the platform's core software. Additionally, deployed infrastructure is aligned in terms of the major and minor software versions to minimize the potential for software incompatibilities and bugs between the central instance and deployed local servers. Parallels to a mechanism within HMIS in LMICs identified by Gebre-Mariam and Bygstad (2019), termed "informatization mechanism," can be drawn. In the paper, they lay out the causal relations of the digitalization strategy of a national (Ethiopian) HMIS. Structural entities of data volume and variety as well as a HMIS reform of paper-based approaches led to a standardization (across data-sets and procedures), an integration (single source for data, one report channel) and an unrealized optimization intended to "create value from data" (enhanced insight, decision-making and process automation) (Gebre-Mariam & Bygstad, 2019).

The abstraction of these two affordances informs this mechanism, depicted in Figure 10. The dynamics of the humanitarian context allows for fast-changing requirements and migrations to emerge; a rationalization of the IS content and subsequent synchronization occurred. They lead to the emerging standardization of IS content and software version, thus a flexible generification: "work processes and actual use determine standards which are adapted pragmatically" (Hanseth & Bygstad, 2015). This standardization strategy matches the highly dynamic humanitarian settings. The focus on working solutions from the bottom-up leads to lower complexity and increases the ability for ICT-based healthcare service innovation (Hanseth & Bygstad, 2015). Underpinning the outcome of this complex techno-institutional dynamic are locally contingent and socially situated innovations and improvisations by actors making sense of the technologies within their context and therefore defying fundamental notions of controlled determinism (see Orlikowski, 1996).
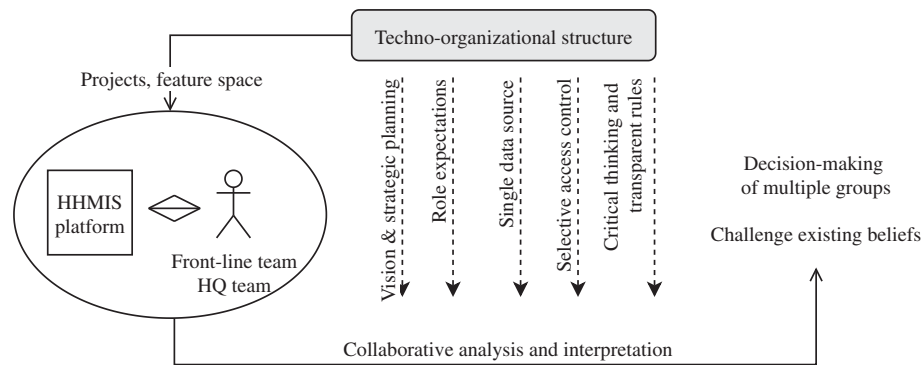
4.3 | The collaborative and mobile capabilities mechanism

The third mechanism is described via two not fully actualized affordances. These have not yet materialized because the technical feature of the HHMIS platform is not yet available, or it is not implemented across and promoted within the organization due to limited feature availability.
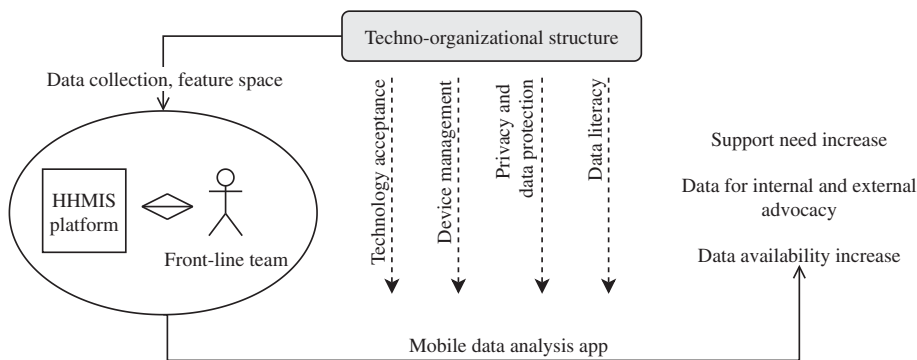
The first affordance relates to the ability to collaboratively analyze data directly within the HHMIS and is visualized in Figure 11. The enabling condition is an organizational need to discuss project-based data for strategic decision-making and the feature space provided by the HHMIS. A systematic literature review by Penn and Dent (2016) identifies 10 either technical or social factors that must be enhanced in a balanced approach and in a certain order to attain effective decision-making within an organization. Parts of the technical factors are not fully covered (e.g., the HHMIS is not the organization-wide data warehouse but the monitoring platform); however, the social factors are deemed relevant: a strategic vision, planning and related dialog, individuals expressing their critical thinking and the setting of transparent rules for the discourse are conditions for collaborative analysis. These factors can challenge existing beliefs by enabling decision-making within multiple groups. However, this is sometimes not the case as one interviewee stated (INT5): "they make decisions and then look for data to back up their decision, but they don't use the data to make decisions. So we are trying to change that so that they do it the other way around." Different roles within the organizations should be accounted for—for example, medical referents who oversee projects do not need, or are not expected to have, the same ability as front-line teams entering data. The features should help to explain and contextualize data with others, that is, the analytical objects presented within the interpretation tool-set. One of the obstacles is a lack of access control, as an interviewee noted (INT5): "I'm in the capital, and I put you in a comment about the project. The person who is tagged in this thread can see the data from other projects who shouldn't have access." Having said that, this can be necessary when multiple groups discuss a problem based on data.
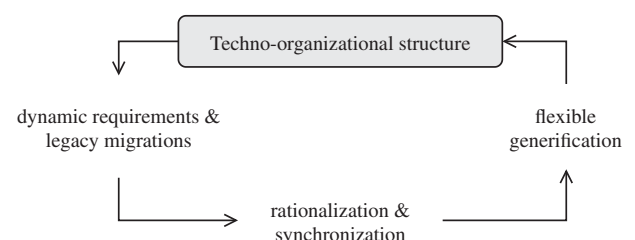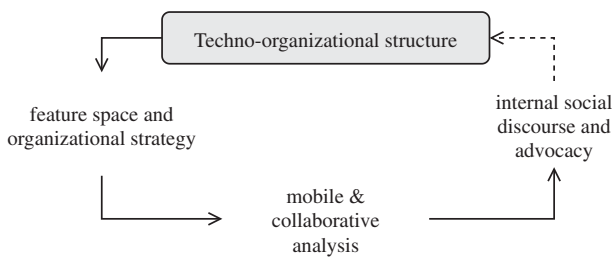
FIGURE 10 Standardization mechanism (adapted from Bygstad et al., 2016)

FIGURE 11 Collaborative analysis affordance (adapted from Bygstad et al., 2016)

FIGURE 12 Mobile analysis affordance (adapted from Bygstad et al., 2016)

FIGURE 13 Collaborative and mobile capabilities mechanism (adapted from Bygstad et al., 2016)

The second affordance (visualized in Figure 12) relates to the ability to easily access data on mobile devices, a previously identified goal of MSF (Braa & Sahay, 2017). The current generation of mobile apps that seamlessly integrate with the platform focus on data collection. Interactive data analysis on mobile devices is not provided as a built-in feature, and the mobile application for accessing pre-made analytical objects has been deprecated (marking the end of official support and development). Thus, this affordance is not actualized.

The enabling condition is that data is collected and available through the platform and the feature space provided by the platform. A stimulating condition, based on previous research on technology acceptance, indicates that the conjunction of well-informed technology design, perceived usefulness and perceived ease of use will increase the intention to use mobile health applications (Mohamed et al., 2011). Mobile device management is required to efficiently administrate a large number of phones or tablets. Privacy and data protection measures must be in place, especially in regard to personally identifiable information of patients. In order to use a mobile application effectively, a certain data literacy is required. The outcome in theory would be increased data availability in the field: larger devices, such as personal computers, do not need to be carried around anymore. One interviewee (INT3) stated: "… we cannot expect them to bring the laptop. I think that would be way easier with a tablet […] That's why the paper works better, because they put the paper in the pocket, because they would use it anytime. So I think anything that tries to be similar to paper in that sense, or to a notebook, would work." Mobile devices can be more easily brought to meetings or training sessions with

internal staff but also external stakeholders, for example during meetings with staff of the country's Ministry of Health, "to make it a bit more interesting for everyone to know, to give an idea what we are doing" (statement of INT4). This advocacy is enabled as soon as a certain level of interactivity with data and the counterpart is required. It can be expected that one of the outcomes is an increased need for individual user support and training as more devices are in use that need to transmit data. It also requires substantial institutional investments in hardware and software.

This mechanism is informed by two not-actualized affordances due to unrecorded contextual conditions (Bygstad et al., 2016). The feature space and organizational strategy allow a mobile and collaborative analysis, which in turn enhances the social discourse for evidence-based decision-making. However, both require a minimal level of connectivity to the Internet to be minimally operational. Another structural aspect is the sustainability when collaborating with local institutions, as one participant noted (INT4): "with the [advantages of the] digital, the sustainability is a problem, because once we leave they [the Ministry of Health] will not maintain all this, and with all the updates of the software I don't think it will work when we leave... they are back to paper." Thus, this mechanism promises to increase internal collaboration but is limited in its discourse with local "external" institutions and is depicted in Figure 13.
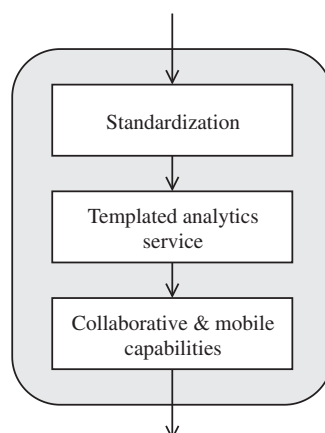
4.4 | Mechanism interactions

Since three identified mechanisms emerge within the same context, the same platform but multiple teams, it is possible to reason on how these mechanisms might interact based on the conditions and outcomes. A listing of the mechanisms and related affordances is found in Table 3.

The interaction of the mechanisms is visualized in Figure 14. The standardization mechanism (the quantified use, lean content, generification and synchronized distribution) positively influences the analytics service mechanism (more specifically, the enabling conditions of its affordances: shared accountability, responsibility and feature space). The analytics service in turn enables the collaboration on the provided dashboard and dashboard items as well as the usage of the same dashboards on a (not available) new or integrated mobile application.

The additional internal social discourse on data can again be input to the mechanism of standardization (institutional capabilities and processes). However, the influence of the collaborative and mobile capabilities mechanisms was not further studied due the limited empirical evidence of nonactualized affordances.

TABLE 3 Mechanisms and related affordances

Mechanism	Affordances	Actualized
Templated analytics service	Templated analytical object provision	yes
	Adaptation of provisioned analytic tools	yes
Standardization	Rationalization	yes
	Synchronization	yes
Collaborative and mobile capabilities	Collaborative analysis	no
	Mobile data analysis	no

FIGURE 14 Mechanisms interaction

TABLE 4 HHMIS mechanisms

Mechanism	Definition
Templated analytics service	The processes of providing templated analytical objects by intermediary digital health experts to frontline staff leading to relationships of users, producers and providers of data and related analysis tools.
Standardization	Dynamic requirements and legacy migrations inform a rationalization and distribution of IS content leading to a standardization strategy of flexible generification.
Collaborative and mobile capabilities	The process of strategizing the feature space for mobile and collaborative data analysis for increase in internal social discourse and advocacy.

5 | DISCUSSION AND PRACTICAL IMPLICATIONS

The application of critical realism and affordance-based data analysis has helped to explore a limited set of issues in humanitarian health management information systems. This study pointed to three mechanisms in operation that influenced digitalization efforts and the use of information in project monitoring. A summary of the definitions of the identified mechanisms are given in Table 4.

The mechanisms identified in this study provide arguments for strategic developments and further research.

First, further research in the provision-use relationship of the analytics service is needed, as making "the system easy to use" is one factor in achieving greater acceptance (Mohamed et al., 2011). Additionally, it might prove beneficial if a solution can help to effectively balance the competing demands between time constraints of front-line staff and required maintenance of analytical items in order to improve the efficiency for decision-making. One path for further research is predictive analytics which—in theory—reduces the time necessary for human input in decision-making (Kasthurirathne et al., 2020).

Second, continuing the strategy of flexible generification is recommended as it is the most innovative standardization strategy (Hanseth & Bygstad, 2015). Furthermore, the synchronization affordance is one step closer to ICT-enabled real-time data (RTD) systems. RTD systems facilitate tactical adaptive management (iterative corrective action in program implementation), which acknowledges that changes are inevitable and programs might need to be altered in response to unexpected forces, especially in humanitarian work (Barnett et al., 2019). RTD systems, however, are currently limited in their ability to inform most strategic adaptive management as neither the timely provision of data nor accuracy of data determines adaptive success (Barnett et al., 2019). Thus, further research into the enablers and barriers of information use within RTD systems is necessary.

Finally, the development and use of platform-based collaboration tools in combination with mobile analysis technology more closely suited to the needs of front-line teams is a promising area for further research and development.

6 | CONCLUSION

This study explored the generative mechanisms in a globally operating humanitarian medical organization. It focused on the outcomes, conditions and structures of information use for project monitoring, drawing on a critical realist approach. It posed the research question: *which generative mechanisms contingently lead to effective use of information for project monitoring in international humanitarian medical organizations?* It identified three mechanisms through an aggregation or abstraction of six affordances. Through that, the study provided an implementation of a critical realist case study in IS research, specifically an application of the analysis framework by Bygstad et al. (2016) to identify generative mechanisms. The purpose of the research was to provide explanation and not prediction. Nevertheless, it is able to provide arguments for more research on analytic service relationships, real-time data systems and collaborative and mobile data analysis in humanitarian health management information systems.

Aid organizations act in highly dynamic, complex and unpredictable environments and need to deal with transitions from immediate needs to long-term development. All throughout they are expected to prove their accountability and effectiveness. Here, data and information use cannot be isolated from the structures in which they occur. As irreversible life-or-death decisions are made based on increasingly digitized content, it is important to illuminate IS-related patterns and processes. The findings demonstrate that mechanism-based explanations can be useful in theory-building in IS research. The study attempted to build upon the existing but limited empirical evidence in humanitarian health information systems.

In building IS theory through the philosophy of critical realism, empirical generalization is considered valuable and often the first step for future studies (Tsang, 2014). The subsequent or parallel step of theoretical generalization is largely based on the process of retroduction: the logical argument explaining what conditions and structures must exist in order for the set of events to be enacted. In that way, the findings discussed in this study are not applicable to other settings (such as another organization) as the mechanisms (including their contingent conditions and structures) that cause the outcomes cannot be replicated. In place of prediction, the study provides insight into how and why a similar mechanism could lead to different (or similar) outcomes in a different setting (Wynn & Williams, 2012). Additionally, the approach utilized in this study of

conducting interviews, document reviews and affordance-based qualitative data analysis can provide methodological guidance for practical implementations in other humanitarian organizations. Understanding the socio-technical patterns in their information system and wider context can inform strategic developments, for example through analysis and subsequent strengthening of identified conditions.

6.1 | Further research

This case study has focused on organization within the humanitarian medical sector. Expanding the scope to further domains, and including multiple organizations in a multi-case study, can increase the validity of the findings. This expansion also might render identified mechanisms less relevant in light of causally more stringent mechanisms, as only the mechanisms that have the strongest explanatory power and empirical evidence are to be explored further (Bygstad et al., 2016; Wynn & Williams, 2012). However, the findings in this study—identified affordances and generative mechanisms as well as the methodology—already provide material for reasoning about explanations of phenomena in humanitarian health information systems.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare. Full disclosure: the corresponding author declares that he was a contractor with a company that provides ICT services (BAO Systems) to the organization under study (MSF) prior to the start of his Master's program of which this article originated. The company helped to provide access to key informants but was otherwise not involved in this study in any other form. The author also declares the intention at the time of writing to be a contractor again with the company after successful graduation.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

APPENDIX A

Interview guide

This appendix shows the interview guide that informed the interviews.

Script prior to interview

Introduction of researcher.

Goal of research.

Time expectation.

Consent gathering for audio recording.

Ask if interviewee has any questions for researcher before start.

Introduction

What do you and your team do on a typical working day?

Main part

Can you tell me about how you use the HMIS platform?

Do you have a specific goal in mind when you access it?

What type of constraints on the level of ICT (software, technology) do you face if you are in the field and use the HMIS platform?

What type of data does your team use to support project activities?

If you compare the new online platform to the previous method of data collection and use, what advantages and disadvantages do you face during your work?

To which entities do you provide or share data-based products (e.g., reports, analysis pieces) (inside or outside your Operational Center) and how?

How many times per year, and through which communication channels, are projects adjusted or adapted based on data?

How and with whom are targets for the measurement of project objectives defined?

Are there other ICT to support project-based decision-making used?

Contact gathering and closing

Would a person, department or unit come to your mind to talk to that could further clarify or extend the points you mentioned?

APPENDIX B

Data analysis

This table shows how a mechanism was retroducted from collected data, to affordances, to mechanisms, on the example of one mechanism.