Emerging Insights on Building Infrastructure for Data-Driven Transparency and Accountability of Organizations

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Abstract
Diverse domains including education, healthcare, and business are attempting to harness IT and data science to govern individual and organizational performance. Largely centered on performance measurement, data-driven accountability tools are used to engineer work processes according to best practices and transfer policy to practice through tying quantitative outcomes to consequential valuation schemes. In this early work, we present preliminary insights from a multi-sited ethnography of ongoing development of infrastructure for data science being developed for purposes of organizational accountability in the healthcare. The aim is to describe key concerns in the design of 'infrastructure for accountability' (consisting of the array IT, organizations, organizational relationships, standards, and roles being developed to undergird performance measurement). Some initial considerations for design of infrastructure for accountability include dual functions of the data, communication hierarchy, emergent seams, and bridging installed bases and communities of practice. This research has implications for researchers, designers, and managers of infrastructure for accountability, as well contributing ethnographic empirical insights into social and organizational implications of creating the data-driven world.
Keywords: data, information infrastructure, accountability, organizational practice, performance improvement
Citation: Pine, K., Mazmanian, M. (2015). Emerging Insights on Building Infrastructure for Data-Driven Transparency and Accountability of Organizations. In *iConference 2015 Proceedings*.

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1 Introduction

Organizations and the individuals working within them are collecting and producing data to make work performance transparent to an unprecedented degree [31]. Performances of work are made visible via quantitative measurements of work processes and outcomes. These measurements are meant to capture the quality of organizational products and services, the productivity of workers and organizational systems of production, and the effectiveness of organizational functioning. Performance measurements are used internally in management and quality improvement to assess and change organizational processes. Organizations also engage in externally facing performance measurement through providing data to both governmental and non-governmental oversight bodies. Algorithmic rating and ranking schemes are applied to determine how a particular organization is performing in comparison to a larger set of peer organizations. In the case of public sector services such as healthcare the results of these valuation schemes are often tied to institutional systems of reward and sanction for organizational performance.

Thus, accountability practice at present hinges on the capacities of information technologies [12] and the accountability endeavor is a major driver of the influx of hardware and software applications into organizations [44]. The development and implementation of IT and expanding capacity to collect, store, and transmit data have aided in the proliferation of performance-related data and an expansion of tools, techniques, and practices for using this data to evaluate performance. Although systematic application of quantified measures to management is not new, the recent wave of data-driven management has advocated for expansion of the number of dimensions along which organizations are evaluated and development of non-financial measures to audit performance, such as adherence to evidence-based "best" practices [32].

In addition, social, political, and cultural forces have driven a larger trend toward audit and oversight of work performance. In recent years, scholars such as Powers [31] and Pentland [27] have pointed out that the degree to which public organizations are held accountable is both increasing in degree and changing in kind, such that there has been an "explosion" of demands for accountability of organizational performance via evaluation processes, indicators, and other audit tools. Major factors underlying the audit explosion are hypothesized to be: adoption of New Public Management; social and cultural demands for

increased transparency and oversight of government and corporations stemming from the public; and importation of industrial engineering principles into the public sector.

Thus, two forces compel current organizational practices of data-driven accountability. First, is an increasing demand for accountability (providing transparency and evidence of correct action to the public, consumers, and other stakeholders). Second, and related, is an escalation of a new paradigm of "data-driven decision making" [8] which is largely concerned with deployment of data and data analytics for myriad aspects of business, including quality assessment and improvement. Data-driven transparency and accountability practices take multiple forms. The empirical case that forms the basis for the present work is ongoing development of infrastructure for creating and reporting organizational performance measurements in the healthcare sector. Performance measures "quantify how well the activities within a process or the outputs of a process achieve a specified goal" [19]. Performance measurements are tools for making visible, evaluating, managing, and regulating performance of workers and workplaces in both the public and private sector. Examples of performance measurements include evaluating schools against certain benchmarks for standardized test scores or evaluating call center workers according to length of time per call and volume of calls handled. Managers, administrators, and public officials use these metrics to distinguish adequate performance from poor performance and impose rewards and sanctions based on these results.

ICT-embedded information infrastructures are central to the vision of data-driven accountability. Here, we draw a definition of infrastructure from Bowker, Baker, Millerand, and Ribes' [5] articulation of infrastructure as a "…broad category referring to pervasive enabling resources in network form." In this conceit, infrastructure includes the technical, social, and organizational components enabling knowledge work. This definition sees infrastructure as inherently relational, and also necessarily inclusive of the individuals—designers, users, mediators, managers, administrators, and so forth—associated with information infrastructure. A rich literature has described the design, development, sustainability, and related concerns of large-scale infrastructures (i.e. cyberinfrastructure) for supporting scientific research. The systems that are leveraged as part of accountability practice extend beyond the local, making an infrastructure perspective critical [25]. Performance measurement relies upon a supporting infrastructure that enables data to be "…acquired, collected, sorted, analyzed, interpreted, and disseminated" [32, p. 158]. Infrastructure for accountability of healthcare organizations involves medical records systems such as electronic health records [45], databases, standards, classification systems, coding schemes, and scientific systems of knowledge production. Further, it involves a wide array of community resources such as collaboratories, code dictionaries, data repositories, and so forth, as well as the complex array of organizational stakeholders such as funding agencies, large scale consumers of healthcare (insurance companies and the federal government), quality improvement organizations, performance consultants, measure vendors, and so forth. Additionally, online social media tools are used to communicate the results of performance metrics and even rank those evaluated [36].

A crucial point here is that in many settings infrastructure for doing the applied science of data-driven accountability does not yet exist in a form that comes close to realizing visions of quality improvement and regulatory stakeholders. At present, many organizations are struggling with "a problem of infrastructure" [11]. This refers to a lack of infrastructural capacity to leverage data for data-driven decision-making and reporting that is out of synch with organizational and institutional expectations and imperatives for data mobilization and reporting. In such cases, organizations have to produce data and performance measurements in the absence of tools and capacities to do so, which can place undue burden on organizational and worker resources. Gaps in infrastructure for accountability become especially problematic when considering the fact that data-driven measures are increasingly weighted in management and regulation and tied to state and federal law. Performance measurements are often tied to valuation schemes that can gravely impact public perception, resource allocation, and even sanctions such as termination or workers or closure for under-performance.

Thus, there is a pressing need to investigate how infrastructure for accountability, as with other types of infrastructure such as e-science infrastructure, can be fruitfully developed and supported. Further, there is a need for nuanced understanding of the implications of "creating a data driven world" for individuals and organizations. Further, there is a need to examine the particular socio-technical-organizational challenges, political engagements, and moral tensions that arise from building accountability infrastructures. This paper is an early work, providing an initial empirically based look into a multi-sited ethnography of design and development of accountability infrastructure for healthcare regulation and quality improvement in the United States. In particular, we are examining the development of accountability infrastructure for measuring and intervening in the performance of hospitals delivering maternal and child healthcare services. We use multi-sited ethnographic data of on the ground efforts to

create and deploy data-driven performance measurements along the lifecycle of data collection. Untangling the threads that go into building infrastructure for accountability reveals a complex array of intertwined social, technical, and organizational systems, standards, artifacts, and relationships that must be navigated, bricolaged, and otherwise leveraged in an attempt to assemble infrastructure for performance measurement. Over time, we aim to uncover specific design and development issues related to infrastructure for accountability that will help stakeholders to design, develop, manage, and sustain such infrastructures. No less important, we critically interrogate the political and moral underpinnings of the measurements, standards, and valuation schemes that are being designed into this information infrastructure.

2 Relevant Literature

In CSCW and HCI research traditions, two lines of work have explored the concept of accountability [16]. Scholars working in the ethnomethodological tradition to study work use the term 'accountability' to denote a central feature of the practical organization of everyday life, referring to the ways in which people make their everyday activities "visible-rational-and-reportable-for-all-practical-purposes" [18, p. vii]. Accountability has also been explored as a concern of information systems designers seeking to make their design processes visible and accountable to stakeholders [8]. Influential work in human-computer interaction has brought these perspectives together, mobilizing ethnomethodology to inform understandings of accountable systems design [13, 14, 16].

In contrast to this rich body of work, we are not concerned with accountability of design processes writ large. Rather, our concern with accountability focuses on *the array of information tools and practices through which organizational performance is made visible (largely through quantification), evaluated, and regulated—that is, tied to policy and other systems of reward and sanction.* This includes a concern with the quality of data, measurement, and interpretation practice itself. Two literatures have contributed to our understanding of this phenomenon: literature on measurement and accountability and literature on socio-technical information infrastructures. Here we briefly review these streams of thinking to and use them to motivate our own empirically based investigation of emerging socio-technical infrastructures for data-driven accountability.

Measurement and accountability

An old management adage holds that "you can't manage what you don't measure." Visibility, oversight, and regulation via the exchange of accounts of work has long been a feature of organizations. A historical perspective on information and management reveals that the practice and material forms of accountability have shifted along with technological development and the emergence of modern organizational forms [46]. Yates [46] describes how information technologies such as the telegraph and copiers were part of a pervasive shift in management practice that occurred between the late 19th and early 20th century. Management became increasingly hierarchical, and control was exerted by those at the top of the hierarchy over those below through the exchange of communications about work activities and performance.

The past few decades have seen a marked rise in interest with accountability in and of organizations [26]. As Orlikowski & Scott [36] describe, organizations are held accountable to a wide variety of stakeholders (public, government, clients, special interest groups, and so forth) and this requires an examination of how organizations in turn "hold themselves account" (p. 27). What is institutional accountability and what does it encompass? Sauder & Espeland [35] provide a succinct and useful overview:

> *Accountability has become an expansive and elastic term for transparency, improving decision making, containing bias, and enhancing productivity. Audits, assessments, measurement-driven instruction, management by objective, new public management, total quality management, risk assessment, clinical guidelines, and best practices are a few of the strategies devised for achieving accountability. All rely on performance measures such as service statistics, indicators, standardized test scores, score cards, ratings, cost–benefit ratios, and rankings (p. 64).*

Thus accountability is not a single thing, but a collection of tools and practices, all centered around measuring organizational performance, that are aimed at making organizational work visible, and thus manageable to external entities.

Scholars have noted that where accountability used to take the form of a wider variety of tools and practices, in recent years accountability is almost always linked to performance measurement [35] and related audit activities. Quantitative measurement, commensuration, ranking, and feedback involved in performance measurement are predicated on and a driver of rapid changes in technology for data creation and storage [12]. Exploiting emerging IT applications to capture and analyze data on organizational performance is being heralded as an essential feature of management in both the public and private sectors [23]. Studies of emerging ranking systems enabled by web 2.0 capabilities find that not only do ranking systems reconfigure accountability—for example by holding organizations accountable to a diffuse crowd of consumers rather than to specific rating organizations—but that organizations also reconfigure their behavior around the rankings. Thus organizations begin to work in terms of accountability mechanisms [35, 36].

Despite indications that material shifts in accountability practice centered around digital tools are exerting tremendous effects on work and organizations, thus far, research in CSCW and HCI has focused largely on development of cooperative work systems to support coordination and collaboration of central work functions [15]. But, information technologies such as workflow systems are designed specifically to facilitate data-driven accountability, and even to audit practice at the moment it is taking place [28, 45]. Such functions are of high consequence to workers and workplaces, and the accountability function of workflow technology is a primary reason that systems that are not ideal remain in use [16].

Research that does exist on data-driven accountability tends to focus on developing particular tools for enhancing data extraction and compilation of performance reports [i.e. 11] and process mining [43] from information systems. Thus, there is a need to further explore the design, development, and use of sociotechnical work systems that foregrounds accountability (centered largely performance measurement, audit, and feedback) as a central feature of these systems. Research in related fields has examined the sociomateriality of accountability and accounting. Kallinikos [21] describes how the imposition of algorithms embedded in autonomic ICT systems on daily life is a double-edged sword presenting both risks (i.e. offloading accountability to algorithms at distance from people, potential looping effects of profiling) and opportunities (i.e enhanced opportunities for social legibility and self-reflexivity). A sociomaterial perspective reveals that these risks and opportunities are inherently bound up in one another, and accountability is emergent, thus re-configured, in practice.

Making organizational practice measurable is a massive endeavor, driving the development and implementation of new IT, organizations (such as data centers), data services, roles, and complex organizational relationships necessary to produce and deploy performance measures. Despite a recent body of work that focuses explicitly on data-driven accountability functions, there has been a lack of attention to the infrastructure, social and technical, that underlies performance-based accountability endeavors.

Information Infrastructure

Studies of information infrastructure have taken place in a wide variety of empirical domains. An especially rich body of work focuses on building and facilitating collaborative infrastructures for e-science [i.e. 3, 4, 15, 22]. This body of work is concerned with creation, deployment, and maintenance of tools for supporting scientific collaboration across distance. This includes creating repositories of shared data and boundary objects (standards, forms, classification schemes, and information systems) that function across diverse communities of practice [39] as well as the social and cultural dimensions of data sharing [22, 32].

Another recent body of work focuses on collaborative systems employed during the course of work, or “working infrastructure” [30]. Information systems often take on characteristics of infrastructure in that they are interconnected and high in complexity, embody multiple layers of inter-operable standards, and are invisible in use except upon breakdown. Taking this approach, the medical record itself could be seen as infrastructure [4] that scaffolds medical and organizational work, as can large-scale information systems that cross spatial and temporal boundaries, such as enterprise resource planning (ERP) systems [25]. Such scholarship informs design of IT-embedded sociotechnical work infrastructures in multiple ways, such as helping designers to mindfully target sections of a work infrastructure for design and heed layered inter-connections between standards both internal and external to a particular setting [30].

Despite this rich body of work on design, development, and use of information infrastructure, research that looks specifically at infrastructure for accountability of work and organizations—namely measuring organizational performance for audit, regulation, and improvement--is rare. While research on development of infrastructure for scientific practice is quite informative in examining infrastructure development on a variety of cases, the unique attributes of accountability, which involves a complex

interplay of applied quality science, management, policy, professional knowledge, and morals presents a unique set of tensions and challenges for infrastructure researchers.

Thus, developing infrastructure for data-driven accountability presents new and different challenges for infrastructure research and development. Reports, indicators, measures, and other artifacts produced to make activity visible and accountable typically happen using data that is produced as part of performing primary work activities—and, with the development of information systems with increasing data storage capacity, the amount of data that is created and stored simply in the course of going about work continues to escalate dramatically. At the same time, expectations and requirements for data-driven accountability functions premised on this expanding store of seemingly rich and ready at hand data are mounting, and in many cases large consequences are attached to the outcomes of performance data. Studies of accountability infrastructure are a pressing concern for researchers, designers, users, policy makers, and consumers of public services who are investing in and relying on data-driven accountability in a multitude of domains.

3 Methods

The present case centers on development of infrastructure for performance measurement of maternal and child health. Ethnographic fieldwork (observations and interviews) is currently underway in multiple sites, including a hospital system with six hospitals and a shared administrative center, a statewide quality improvement agency and a maternal/child healthcare data center housed there, and a the obstetrical unit of a standalone teaching hospital. Observations and interviews are also being conducted at medical records departments, best practice and physician leadership meetings, information services, quality improvement, maternity services, and the statewide data center. Outside of these California field sites, we are conducting interviews with stakeholder organizations integral to developing artifacts and arrangements for a larger accountability infrastructure. These include people involved in the process of selecting hospital quality measurements certified by the NGO (who has been charged with measure selection and refinement and the directors of a nationwide effort to use a consensus-based process to standardize definitions of obstetric terms). Within these three larger sites, our data were collected within multiple local sites involved in developing systems for collection, deployment, and feedback of performance measurements and in doing the on the ground work of producing data for these purposes. This ongoing fieldwork has thus far encompassed the period during 2009-2014.

At present, there is, to borrow Colombino et al's [11] term, a "problem of infrastructure" in our empirical context. Data is available—in a sense--because it is increasingly collected, stored, and (in theory) extractable via EHR systems and other IT-embedded work systems. Further, there are mounting requirements for data reporting (in the form of requirements for national quality measures and internal quality indicators and benchmarks). However, actually producing usable information from stores of potential data is still incredibly difficult. An educator and quality improvement leader working in one of our hospital fieldsites described the effort involved in trying to extract usable data for a particular initiative related to physicians' cesarean section rates:

> *"It is excruciatingly difficult work to figure all those system issues out and I am currently doing some of that. So we can't go public with things like publishing the docs c-section rates until we know we have accurate data…It's incredibly complex, and it takes hours of time, literally."*

The situation is one where there is a lack of infrastructure to facilitate creation, reporting, and interpretation of data. Our fieldsites, operating at different levels of the accountability landscape, are currently developing infrastructure to support these evolving performance measurement practices. All of the hospitals have fully implemented EHR systems. The hospital system is currently developing data warehouse architecture, using an Oracle database management system, that will automatically collect data elements from the EHR and other systems and provide data analytics tools for clinicians and other end users. The statewide data center has introduced a fully functional data center that merges vital records data with hospital-provided data to create a tool that allows hospitals to compare their data against other hospitals across the state. This tool is currently being re-developed for pilot projects in four additional states. The end goal is to create an ecosystem of nuanced obstetrical data that can be deployed for rapid cycle assessment and quality improvement at a scale varying from the hyper local to national. Yet, the infrastructure that would make this situation a reality is far from completion.

We are using an interpretive research approach in which inductive theorizing arises directly from data. As we collect data, the researchers share data transcriptions and develop emerging themes. The primary mode of analysis is writing extensive memos on emergent themes related to accountability infrastructure, going to literature on information infrastructure to compare our findings to existing infrastructure studies scholarship, and re-working our understandings in light of literature and new data on an ongoing basis. The following are some initial emergent themes from data collected for this project thus far.

4 Building for Data-Driven Transparency and Accountability: Data & Emergent Themes

In this section, we present an initial attempt to examine, using empirical data, some of the key characteristics of the socio-technical accountability infrastructure. Throughout, we refer to literature on information infrastructure and cyberinfrastructure, particularly Star & Ruhleder's [39] characteristics of infrastructure, to gain an understanding of the infrastructure development and the ways in which infrastructure for transparency and accountability may diverge from past work on e-science infrastructure or present particular challenges for stakeholders.

Hierarchy of communication

Reporting requirements integral to systems of reward and sanction are a large driver behind development of infrastructure for performance measurement. Classic studies of infrastructure show that infrastructure is nested within other structures, social systems, and technologies [39]. Our empirical case reveals that research on accountability infrastructure must pay particular attention to the embeddedness of information infrastructure in systems of organizational and institutional management, regulation, and governance within which the infrastructure resides. Yates [46] describes how control is exerted through demands for communication of certain information in certain forms "up" the hierarchy of an organization such that those below must pass information upstream. This transference of information passes through many levels of hierarchy. The relationship between hierarchy and information demands is not explicitly articulated in past definitions of infrastructure such as Star & Ruhleder's [39].

Healthcare is highly regulated and accountability infrastructure is necessarily entangled with professional, political, legal, financial, and other structures. Thus, accountability requirements are prone to exogenous pressures on healthcare organizations. Since external reporting accountability involves transferring data "upstream" for evaluation, new imperatives for data often come without prior warning and demand rapid development of novel resources and capacities. The database team lead at our hospital system described how he would 'like to get to a place where we are not always playing catch up.' For example, the hospital currently has the capacity to pull data elements from ICD-9 codes and certain other administrative data. The majority of quality measures utilize ICD-9 data and some utilize birth certificate data. However, a newly implemented measure of severe maternal morbidity [28] is designed to understand the severity of an obstetrical emergency. This measure requires a number of additional data elements which have not been used on prior measures, such as the number of days a woman was kept in the hospital. While it may seem simple to gather such data given the capacity of the EHR and associated relational database, it is actually incredibly complex to pull a new data element from an administrative data set that has not previously been cultivated for this purpose. Data must be located, quality of data assessed, idiosyncrasies identified, and inevitably a range of nearly intractable problems are discovered in the "real messy world of data" as one administrator describes it. Far from being able to create a seamless data system in advance, at present it seems that only through encountering new data demand do our fieldsites face the "messy reality" and untangle the snarls which are inevitably encountered in cultivating and implementing a new data source for performance measurement. There is a feeling that the team cannot predict or even anticipate what new requirements may come, leading to a perpetual need to innovate in order to gather, analyze, and report data; since these activities are incredibly high stakes, hospitals may have no choice but to go to great lengths to meet reporting requirements, and the constant novelty and rapid pace of change may hinder development of functional accountability infrastructures that ease the burden on organizations.

Thus, a major difficulty of developing infrastructure for accountability in our case is that unlike in many e-science cases, such as the Long term Ecological Research Network, there is not a central organizational body here. Rather high-stakes imperatives for delivery of standardized performance measurements that come from a number of oversight organizations and hospitals are required to meet these demands, predicated on the capacities of networked information technologies. A complex but somewhat diffuse network of stakeholder organizations, including collaboratories, data centers, measure

vendors who report data on behalf of hospitals, consultants, and professional organizations is evolving to help local hospitals create, report, and parse their performance data. But there is no coherent organizing system at work, and demands set by oversight organizations for certain measurements happen out of concert with the web of technical, social, and organizational resources encapsulated by this diffuse network.

Data have multiple "encumbrances"

Our field sites are currently developing infrastructure that will allow them to meet external performance measurement reporting requirements. Hospitals across the country must report the results of performance measurements on the same set of quality measurements, administered by a number of governmental and non-governmental oversight organizations. Since selection of performance measures for evaluation of hospitals across the entirety of the organizational field is based on a principle of sufficing with data—selecting data that all hospitals will have available in a standard format—performance measurements use data elements largely drawn from standardized data gathered for administrative purposes. For example, in obstetrics, the majority of data elements for performance measures come from ICD-9 codes and birth certificate data. However, these data sources have multiple, often competing *encumbrances*. ICD-9 data is applied to medical records for billing purposes. But, this data also form a crucial data element for performance measures. In our observations of coders, we found that coders follow a process of querying physicians for ambiguous chart data before applying codes. But, ambiguous data is very common—medical records coding requires a high degree of skill for this very reason. Coders cannot query physicians for every piece of ambiguous data, because work would grind to a halt. In deciding when to query physicians, coders prioritize queries that will have financial ramifications. In practice, the focus on maximizing financial reimbursement means that ICD-9 data have two purposes that are often at odds. An administrator in the hospital system described how, on one hand, these data must maximize financial gain for the organization, and on the other hand they are supposed to represent "clinical truth" (or as close to 'truth' as possible).

Thus, a key concern for developers of infrastructure for accountability, from designers of performance measurements to developers of information systems for querying databases and extracting measurement data, is the need to balance tensions between quality and availability of data. While data extracted directly from the medical record would be higher quality, the cost of extracting such data would be incredibly high compared to the existing repository of structured data available from existing infrastructure for coding medical charts. Building effective infrastructure for performance measurement will require both tools for assessing the quality of such second-order data, as well as capacities for understanding what one can infer from performance measures given the sources of data, or "provenance" of data, that they utilize. Consumers of performance measurements who are attempting to understand a hospital's performance on rating and ranking schemes need to understand what data underlie final measurements, and organizations being evaluated as a cohort need to find ways to collect data in ways that make their measurements comparable with peer organizations. Our fieldsites are currently working on design solutions that will embed knowledge about how origins of data sources and measurement algorithms within the interfaces for consuming hospital performance data. For example, the statewide data center is currently developing a data analytic tool that will supply prompts to end users of the tool related to the source of the data elements and the algorithm used to calculate the performance measure as they are actually using the analytic tool. The aim is to provide end users with both performance data and a sense of the data's origins and particular methods for calculating a measure. Well functioning accountability infrastructure will promote reflection on data, and its limitations, as well as reflection about the algorithms used to produce data, and the relationship between the two.

Emergent seams

According to Star & Ruhlder [39], transparency is a core aspect of infrastructure, in the sense that it does not have to be reinvented each time or assembled for each task, but invisibly supports those tasks. However, due to dual purposes of accountability infrastructure described above, persistent exertion of exogenous pressures for new and different kinds of data and measurement, and the complexity and multiplicity of information systems involved in internal and external data activities, accountability infrastructure seems to possess a quality of persistent ad-hoc-ness.

Attempts to infrastructure for data-driven accountability can reveal opacities and "seams" in existing information infrastructures. Where an infrastructure may have been functioning with a relatively high degree of transparency, when an organization attempts to draw on the infrastructure for activities

such as performance evaluation and external ranking, large seams suddenly become apparent where the infrastructure was previously functioning smoothly.

For example, many of the perinatal core measures require data from a birth certificate database; this data is collected for the state's department of vital records. When hospitals began attempting to pull data elements for quality measures from birth certificate data, it quickly became evident that the quality of birth certificate data was very poor. Data that had been sufficient quality for a longstanding vital records infrastructure was highly substandard for quality measurement. Subsequently, the quality improvement organization launched a training program for birth certificate clerks, currently in a pilot phase, to train clerks to more accurately interpret and enter data from medical records.

Additionally, developing systems for data-driven transparency and accountability has resulted in re-analysis of existing standards and in some cases even creation of new classification schemes. For example, when TJC began requiring hospitals to report on the perinatal core measure set in 2012 and the Leapfrog Survey began incorporating similar measures of perinatal quality into their survey, both TJC and Leapfrog made hospital performance in relation to comparison hospitals on these measures available to the hospitals themselves and to the general public. Hospitals were immediately confronted with the high stakes of poor performance on these performance measures, yet high disparity was (and still is) seen among hospitals. In some cases these disparities reflect actual differences in practice, but in other cases they reflect large variations in how practice information is recorded.

Balancing internal organizational reflection and external reporting

The current paradigm of performance measurement [32] being adopted across the healthcare sector and other sectors such as education [37] relies on performance measures fulfilling two functions. First, data-driven measurement is deployed as a process for organizational self-reflection and data-based decision making. Second, data-driven measures are reported to external bodies for large-scale transparency and regulation. Accountability infrastructure must support both of these functions. For example, our hospital system fieldsite is currently engaged in a local quality improvement initiative centered on developing a measure for severe maternal morbidity. Severe maternal morbidity measures have gained some attention from prominent quality improvement organizations, but as of yet no measure has been adopted nationally by one of the large external stakeholders, chief among which is The Joint Commission (TJC). The hospital system contracts Accountability infrastructure must support both of these functions. For example, our hospital system fieldsite is currently engaged in a local quality improvement initiative centered on developing a measure for severe maternal morbidity. Severe maternal morbidity measures have gained some attention from prominent quality improvement organizations, but as of yet no measure has been adopted nationally by one of the large external stakeholders, chief among which is The Joint Commission (TJC). The hospital system contracts with an external vendor, "Truven" for TJC reporting. The Truven tool allows the hospital to upload data sources from the system's EHR, and the vendor then handles sampling, calculation of quality measures, and transfer to TJC for external reporting. While hospital staff can utilize Truven for data analytics, Truven's tool is geared specifically around external reporting, making it inadequate for internal evaluation projects. Since Truven is designed specifically for certain measures collected by TJC and other external bodies, their tool cannot be used to construct a locally usable severe maternal morbidity measure; the vendor only provides analytics for measures that are in wide use. The data warehouse under construction n the hospital system is intended to facilitate local performance measurement and data analytics, but will likely not have the capacity for external reporting of data.

Infrastructure has long been known to grapple with tensions between the local and the universal [41]. While performance measurement occurring internally and reported externally have many similarities, in practice these activities have very different requirements. In particular, externally reported data must adhere to the measurement algorithms and sampling strategies specified by external organizations, and, since these data are compared nationally, typically made publically available, and increasingly engaged in both formal and informal systems of sanction and reward, standards for data quality and measurement accuracy are very high. But, due to the complexity of measurement, producing a high volume of performance data that is both very high quality and rapidly available may be an impossible goal for many hospitals. In contrast to measures reported externally, internal performance measurement may benefit from a tradeoff that values nimble and rapid performance measurement. Thus, developers of accountability infrastructure must grapple with the fact that what is "good enough" data in one instance may not be good enough in another. Further, internal and external measurement activities require different tradeoffs between quality, speed, and agility.

Another issue here is that the fundamental purpose of internal and external accountability activities is quite different. While external measures capture variations in healthcare on a large scale, identify emergent problems at a population level, and place leverage on hospitals to address pressing health issues at a large scale, internal performance measurement activities are often geared around reflection, learning, and local management. Participants in the local hospitals describe using data to explore and provoke; for example one participant described using performance measures to "get the clinicians to ask questions." This quality improvement worker keeps candy in her desk as an incentive to physicians to stop by and learn their personal cesarean section rate.

In contrast, Truven, the core measure vendor, allows hospitals to see chart-level data and to develop graphs depicting hospital performance on core measures, but its lacks the ability to create novel analytics and representations of data. Designing and building accountability infrastructure to support generative reflection and conversation around data will require different infrastructural capacities and tools. The data warehouse design for the local hospital system employs SAP to facilitate novel analytics, but it remains to be seen how the warehouse will fare in automating data extraction from the EHR and other data sources. The capacity to use data in novel ways will depend on how easily multiple disparate sources of data can be brought together to facilitate an ongoing practice of data based generative reflection.

In our field sites, there is not a single system that supports both internal and external accountability activities. In fact, multiple discrete information systems are employed in performing both internal assessment and external reporting. The severe maternal morbidity measure being developed internally, for example, requires data from the EHR system, a standalone blood bank workflow system, and a vital records information system (run by the state). Eventually, the hope is that the Oracle-based data warehouse will automatically extract these data, but perpetuation of multiple systems is a near certainty, and transferring data from one system to another presents multiple ongoing challenges. Truven data must be sourced from the EHR as well.

The accountability infrastructure under development is not one where a single "infrastructure" is likely or even possible. Rather, the complexity of the data ecosystem, high variation in IT resources between different local settings, and multiple functions of data-driven measurement mean that accountability infrastructure will likely be comprised of a multiplicity of information systems. For accountability infrastructure in healthcare to achieve "infrastructure" status, a re-definition of what counts as an "infrastructure" may be required such that an infrastructure comprises a relatively gracefully interacting bricolage rather than a comprehensive entity supporting scientific practice.

Bridging installed bases and communities of practice

A well-established characteristic of infrastructure is that it is built on an installed base and inherits strengths and limitations from that base [39]. Accountability infrastructure is necessarily highly interconnected with the infrastructure of a community of practice. Medical information infrastructure involves a highly complex standardized nomenclature, diagnostic and procedure codes of the sort found in the International Classification of Diseases [6], standard forms and flowsheets for medical history and treatment [4], conventions of practice, and so forth.

The infrastructures for transparency being developed in our fieldsites are built along this installed base of medical information infrastructure. But, the new systems depart from this installed base as well. Performance accountability involves tools for quantifying, ranking, and regulating the community of practice itself. Development of accountability infrastructure involves merging together information infrastructure from the installed base of a community of practice (medical information infrastructure) with an installed base of quality assessment and performance evaluation (largely drawn from industry). This is seen, for example, in the import of engineering models for quality assessment into healthcare.

A key point here is that part of developing accountability infrastructure involves is establishing new capacities for the applied science of performance measurement, including new relationships between clinical, information services, and quality improvement. In the hospital system, a relatively new executive role is that of Chief Informatics Officer. This officer, and those working under him, is charged with bridging the clinical departments and the information services department. As the CIO describes, end users have no idea what the capabilities of the information systems programmers are and programmers do not have clinical knowledge. His role is situated between these two groups. The quality improvement department, which holds specialized knowledge about current medical best practice as well as training in quality improvement science, is integrally involved as well. Each of these overlapping groups is integral to the success of performance measurement, and developing these offices and a new

organizational structure that incorporates integrates these groups and their knowledge must be considered part of the accountability infrastructure itself.

The emergent development of accountability infrastructure in our case is poses challenges to existing communities of practice, who must adapt and develop new practices, skills, and capacities that were not previously required as part of membership. Interestingly, new vocational roles as well as new organizational partners are emerging in response to gaps in skills and capacities that become apparent through the development of accountability infrastructure. In turn, these emerging members of the community of practice in healthcare are shaping the practice of existing members.

Some additional thoughts on developing infrastructure for accountability and transparency

On the ground, the drive for data-driven accountability and the material forms that it takes has real and deep effects for individuals and organizations. The development of accountability infrastructure and production of performance data has become a central activity of work, taking much time and attention of workers. These activities draw large quantities of organizational resources. Further, there is a need to understand the social and political underpinnings of measurement practice. Quantification of performance based on data (beyond financial data) is increasingly the dominant paradigm for managing and regulating workers and organizations [32]. The proliferation of data and trend toward data-driven management are resulting in quantifications of work performance that were not possible in the past. But, as a number of scholars have pointed out, data is inherently social, technical, cultural, and political in origin. Thus, "data must be cooked with care" [7]. Yet, power and policy discourse are inherently inscribed in accountability infrastructure, and these categories can exert large impacts on practice [6]. The increasing consequentiality of data—to determine what is a "good hospital," a "failing school," or a "productive worker," heightens the importance of data quality and measurement practice.

Developing and implementing tools and infrastructures for external measure reporting is explicitly involved in linking governance and regulation to systems of local practice. Thus, large amounts of tension are placed on the system exogenously rather than endogenously-- new mandates for measurement come down before infrastructure is actually in place to handle these requirements. Due to the highly consequential nature of data reporting to upstream interests, organizations go to great lengths to produce data even in the absence of infrastructure to support this activity.

A key potential pitfall here is that the lack of 'good' infrastructure may be masked by the fact that accountability is a high-consequence activity, and hospitals will struggle to fulfill these imperatives using any means necessary. Thus, the lack of good infrastructure may be overlooked. This is perhaps one reason why increasing demands for accountability can have the effect of distracting organizations and workers from primary job activities [36]. It may be wise to caution against embedding data-driven measures in law, or attaching other high sanctions to data-driven accountability, too quickly for this very reason. Otherwise, undue pressure to perform to metrics or face sanction could impinge on the function that accountability is supposed to improve, clinical activities.

5 Conclusion

Many domains at present are concerned with building ICT-embedded infrastructure to support data-driven accountability. Infrastructure for transparency and accountability has some novel aspects that present tensions and challenges for researchers, designers, developers, and end-users. These include dual functions of the data, communication hierarchy, emergent seams, and bridging installed bases and communities of practice. Further, examining the unfolding efforts to build accountability infrastructure sheds light on studies of information infrastructure more broadly. This work-in-progress provides some initially empirical insights based on a multi-sited ethnography of activities to build and implement information infrastructures for both internal visibility of organizational work performance and external accountability, including development of database tools, interactive data analytic tools, tools and services for feedback and reporting of data. Organizational competencies in data quality assessment, statistics, and communication of statistics and measurements must also be developed, as well as new collaborations between multiple vectors who may not create and transmit information without one another, including information services, clinical services, quality improvement, and those workers who are responsible for the "dirty" work of coding and cleaning data and maintaining and querying databases. We present some initial characteristics of infrastructure for data-driven transparency and accountability and key concerns for stakeholders in these developing infrastructures in hopes that we will receive feedback

from the iConference community that will aid in further data analysis and development of theoretical insights for information infrastructure scholars more broadly.

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