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The Complex System Records Model:

Recordkeeping for Wicked Problems

A thesis submitted in partial satisfaction

of the requirements for the degree

Master of Library and Information Science

by

Yee May Chua

2012

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ABSTRACT OF THE THESIS

The Complex System Records Model:  
Recordkeeping for Wicked Problems

by

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Master of Library and Information Science

University of California, Los Angeles, 2012

Professor Anne J. Gilliland, Chair

How does recordkeeping occur within an organization that manages wicked problems? A wicked problem is a complex and intractable problem that requires collaboration among multiple actors. This thesis puts forth the complex system records model to explain recordkeeping in an organization that manages wicked problems. This model states that such an organization uses recordkeeping to perpetuate an organizational reality. Using the case of the President's Malaria Initiative and the method of interpretive inquiry, this thesis finds strong support for the complex system records model and shows how the model better explains recordkeeping in an organization that manages wicked problems than do alternative explanations. Its work in combating the global public health problem of malaria in developing countries illustrates the importance of recordkeeping for its antimalarial operations.

This thesis contributes to archival science by proposing a conceptual model of recordkeeping in organizations that manage wicked problems. Complementing existing models (e.g., the records continuum model), the complex system records model combines perspectives from other disciplines—complexity science, management science, and philosophy—and shows how an organization uses recordkeeping to perpetuate an organizational reality. In addition, this thesis contributes to biomedical informatics by emphasizing the social construction of scientific knowledge. An organization chooses a particular social epistemology of scientific knowledge that shapes the type of information that is used for recordkeeping.

The thesis of Yee May Chua is approved.

Gregory H. Leazer

Ricky K. Taira

Anne J. Gilliland, Committee Chair

University of California, Los Angeles

2012

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## List of Abbreviations

CDC	Centers for Disease Control and Prevention
DHS	Demographic and Health Survey
GHI	Global Health Initiative
HMIS	Health Management Information System
IPTp	Intermittent preventive treatment for pregnant women
IRS	Indoor residual spraying
ITN	Insecticide-treated mosquito net
MCDI	Medical Care Development International
MIS	Malaria Indicator Survey
MOP	Malaria Operational Plan
NIH	National Institutes of Health
NMCP	National Malaria Control Program
PMI	President's Malaria Initiative
RDT	Rapid diagnostic test
RTI	Research Triangle Institute
TNVS	Tanzania National Voucher Scheme
USAID	United States Agency for International Development
WHO	World Health Organization

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# Chapter 1 Introduction

Many nations, international organizations, transnational networks, and scientific communities are simultaneously working to manage global problems in multiple arenas. These global problems are wicked problems, and they are inherently complex and intractable. Malaria is one of the global wicked problems. It is the cause of about one million deaths annually and about 3.3 billion individuals are at risk of malaria infection (Greculescu 2011; Hall and Fauci 2009). Accordingly, government and non-government actors have to collaborate and adopt transdisciplinary as well as transnational approaches to manage wicked problems (Brown et al. 2010; Ney and Thompson 2011).<sup>1</sup> With a lot at stake, billions of dollars invested, many policies implemented, and vast knowledge created, records have been created to capture the trails of these transactions thereby making an organization accountable, trustworthy, and to facilitate coordination among different actors.

This thesis puts forth a conceptual model—the complex system records model—to explain an under-explored aspect of archival science: recordkeeping in organizations that manage wicked problems. The complex system records model provides a theoretical explanation of *why* organizations conduct recordkeeping in a particular way. Organizations conduct recordkeeping mainly to be accountable, to promote transparency, and to create an organizational memory. Archival science studies generally focus on organizations that seek to solve problems in a particular policy domain and within the borders of a single country. This thesis focuses on

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<sup>1</sup> The term “wicked” does not imply that wicked problem is morally objectionable. A wicked problem, in simple terms, is a problem that is intractable. In other words, applying solutions in one domain of a wicked problem could simultaneously alleviate one aspect of the wicked problem and worsen another aspect of the wicked problem. For a deeper discussion on wicked problems and its effect on recordkeeping, see sections 2.1 and 2.2, especially Table 2.1.

recordkeeping in a different type of organization, i.e., an organization that manages a wicked problem that occurs across multiple nations.<sup>2</sup> Recordkeeping differs for an organization that manages a wicked problem because it delegates most of its business operations to third party entities.<sup>3</sup> The U.S. Department of Energy (DOE), for instance, has the mission of maintaining the U.S. energy systems within the U.S. and DOE staff members conduct most of its operations. The United Nations (UN), in contrast, is an international organization with the main mission of managing global problems (e.g., climate change and peacekeeping) and delegates its operations mainly to third party entities. One way in which recordkeeping differs between DOE and UN is that DOE could rely on DOE staff to create records that report the local realities (e.g., the day-to-day operations in a DOE-run power plant), whereas UN relies mostly on third party entity-created records to know the local realities of the global problems.

This thesis builds on recent archival science research that foregrounds the importance of archival science in aiding organizations to meet the “grand societal challenges” in humanity (Gilliland and McKemmish 2011, 2012; McKemmish 2012).<sup>4</sup> The *Archival Education and Research Initiative (AERI)*, for instance, is creating a community of scholars that uses insights from archival science to meet the archival and metadata needs that are arising from these grand societal challenges. This thesis contributes specifically to one of AERI’s grand challenges—

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<sup>2</sup> There is a difference between an organization managing a wicked problem that occurs across *national* boundaries (e.g., malaria is occurring across most African countries) and an organization that is managing a wicked problem that is occurring across *organizational* boundaries (e.g., different Chicago public schools facing the common problem of teachers going on strike in September 2012). The key difference is the geographic scope, i.e., an organization that manages malaria has to coordinate its operations across different nations with different laws and culture; while the 600 Chicago public schools were facing a common wicked problem of teachers going on strike that were occurring in Chicago in September 2012. This thesis focuses on organizations that manage wicked problems across different national boundaries.

<sup>3</sup> Delegation in this thesis is the process where an organization assigns some aspects of its organizational functions to another organization outside its jurisdiction. In the context of this thesis, most of the delegation are a form of outsourcing but this thesis will use the term delegation throughout.

<sup>4</sup> The nine areas of grand challenges identified to date are climate change, peace and security, development, corporate governance, human rights, health and well-being, social justice and inclusion, sustainable communities, and information society and technological change (Gilliland and McKemmish 2012).

health and well-being—by focusing on malaria and using the complex system records model to explain the nature of recordkeeping in the U.S. President’s Malaria Initiative (PMI): the U.S. government’s frontline agency in combating malaria outside the U.S.<sup>5</sup>

## **1.1. Main Argument**

This thesis puts forth the complex system records model to explain recordkeeping in an organization that manages a wicked problem in multiple countries. Based on theories from archival science, complexity science, management science, and philosophy, this model states that recordkeeping occurs within the context of organizational norms and boundaries (physical and psychological). A reinforcing cycle occurs where recordkeeping reinforces an organizational reality that is internalized by its staff and this internalization in turn reinforces the organizational reality that its management—intentionally or non-intentionally—seeks to create.

Using PMI as a case study, this thesis shows that the complex system records model better explains recordkeeping within an organization that manages wicked problem than extant models. First, PMI manages malaria—a wicked problem—by delegating antimalarial activities to third party entities. PMI, therefore, does not have as detailed an understanding of the local realities as do these third party entities. PMI in turn uses the records that are created by these third party entities to create its own records. In addition, these PMI records externalize the diverse perception of multiple local realities and the PMI management in turn devises antimalarial programs based on these records. An aggregation of these records becomes PMI’s organizational memory and perpetuates PMI’s organizational reality. Subsequently, in the next fiscal year, PMI again delegates its antimalarial activities in the form of contracts to these third

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<sup>5</sup> The other global malaria regimes are the World Health Organization (WHO) led Multilateral Initiative on Malaria (MIM) and the Bill and Melinda Gates Foundation led Malaria Eradication Research Agenda (MaIERA).

party entities, and these third party entities report back to PMI with a record of their activities. The complex system records model, hence, uses organizational dynamics as a focal point and emphasizes the importance of recordkeeping in reinforcing an organizational reality.

Taking a step back from the intricacies of recordkeeping processes, the complex system records model also explains a less explored dimension in archival science: an organization's choice of the epistemology of knowledge and the subsequent effect on its recordkeeping. PMI is a good case to illustrate the importance of this issue because at the macro-level, malaria is a wicked problem and the scientific communities—despite nearly a century of scientific research—have no consensus on the most effective antimalarial method.<sup>6</sup> Furthermore, at the micro-level, the complexity of malaria imposes a cognitive overload on PMI staff because they have to choose the most relevant information to input into the records. The perceived relevance of information depends on his or her mental model; and the mental model acts as a cognitive filter for him or her to assess the degree of relevancy of the information.

The complex system records model explains the dual processes at the macro and micro levels. PMI *chooses* a social epistemology of malaria that originates from the epistemic community that is led by the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC). PMI's choice in turn affects its recordkeeping at the macro and micro levels. At the macro-level, PMI's recordkeeping process has an epistemic bias towards the WHO-CDC type of malaria knowledge. At the micro-level, PMI staff members are socialized into this epistemic practice and they filter the information that they key into the records with a potential bias towards the WHO-CDC type of malaria knowledge and antimalarial best practices.

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<sup>6</sup> Notwithstanding the consensus among the scientific communities that vectors transmit malaria, the two most important determinants of malaria transmission within a population are the local geographic conditions and climate.



## 1.2. Contributions to Archival Science

This thesis contributes to archival science in three ways. First, it puts forth the complex system records model that better explains the recordkeeping processes in an organization that manages wicked problem than does the records continuum model (McKemmish et al. 2010; Reed 2005; Upward 1996, 1997, 2000). The complex system records model states that an organization that manages a wicked problem uses records as a way to filter out the irrelevant information, and to reinforce a particular organizational reality. The records continuum model, in contrast, is an all-encompassing model that frames the recordkeeping process in a typical organization in four dimensions—create, capture, organize, and pluralize—and four axes—evidentiality, transactionality, recordkeeping, and identity (Upward 1996, 277-281).<sup>7</sup> Accordingly, this thesis' complex system records model has a stronger explanatory power because it is able to explain why PMI's recordkeeping is occurring in this way whereas the records continuum model is only able to explain the "what" of recordkeeping.

Second, the complex system records model explains how an organization's choice of the epistemology of knowledge affects its recordkeeping. Organizations have the norms, cultures, and work processes that are oriented towards achieving its organizational mission. An organization that manages wicked problems (e.g., malaria and climate change) has to decide *which* epistemology of knowledge to use in order to *choose* the relevant scientific knowledge to justify its antimalarial programs.<sup>8</sup> Accordingly, the chosen knowledge affects the recordkeeping processes because it forms a cognitive filter that affects how the organization's staff members perceive local reality; therefore affect the nature of information that they enter into records. The

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<sup>7</sup> Frank Upward (1996) actually uses a stronger language and implicitly hints that the records continuum model could be used in any organization. Quoting from his 1996 articles, Upward has "labeled the features [of the records continuum model] independently at any time period or professional loading" (277).

<sup>8</sup> Another widely discussed wicked problem that relies heavily on modeling is climate change. For a detailed analysis of the many uncertainties associated with climate modeling and forecasts, see Edwards (2010).

Federal Emergency Management Agency (FEMA), for instance, is the main U.S. agency that deals with disaster preparations and response. FEMA prepared for the impact of Hurricane Isaac (September 2012) based on a social epistemology of the knowledge of storms and hurricanes.<sup>9</sup> The records continuum model cannot adequately explain this aspect of recordkeeping because—unlike the complex system records model—it does not explain how an organization’s choice of the social epistemology affects its recordkeeping.

This thesis’ third contribution is the complex system records model’s greater theoretical utility than the records continuum model: the complex system records model is falsifiable but not the records continuum model. As Frank Upward (1996), one of the originators of the records continuum model, writes, “no separate parts of a continuum are readily discernible and its elements pass into each other...[and] within any implementation environment...the terms will be given specific interpretations and meanings” (277). Falsifiability is a key component of theory building because a theory is an abstraction of reality and it must be subjected to empirical testing. While the records continuum model can be applied to almost *any* circumstances, its unfalsifiability greatly limits its theoretical utility. To be clear, the complex system records model complements the records continuum model by providing an alternative way of explaining recordkeeping in organization. This thesis concurs with mainstream archival science works that the records continuum model is a useful conceptual model for many purposes, and among them is the creation of metadata infrastructure for organizations (Gilliland and McKemmish 2012). A more detailed comparison between the complex system records model and other existing models—life cycle model, information management continuum, and the meta-synthetic support framework—will be discussed in section 2.4.

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<sup>9</sup> FEMA’s preparation activities included modeling the trajectory of the hurricane and estimating the risk of flooding as a result of Hurricane Isaac.

### **1.3. Contribution to Biomedical Informatics**

This thesis also contributes to biomedical informatics: a field that examines the interactions between data, information, and knowledge. Most biomedical informatics studies focus either on representing the biomedical aspects of patient care (e.g., a patient's medical history), thereby improving medical decision making and on creating an electronic health records system that allow seamless flow of information and records. This thesis contributes to biomedical informatics in two ways. First, the complex system records model emphasizes the importance of an organization's choice of the social epistemology of the knowledge that affects its recordkeeping processes. The stream of biomedical informatics research follows a mode of scientific inquiry that assumes that "true" reality exists. Accordingly, these studies design information system that could represent the mode of scientific inquiry and medical decision making that centers on theory validation. Nevertheless, works in the philosophy of science state that scientific inquiry and even medical decision making are socially constructed (Latour and Woolgar 1979; Mol 2002). Thus, the knowledge that a scientist seeks to test and the knowledge that a physician uses to make medical diagnosis are based on a social epistemology of knowledge.

This thesis' second contribution is that the complex system records model better explains recordkeeping within biomedical institutions (e.g., research institutions and hospitals). Records such as the hospital CEO's annual report to hospital shareholders are *the* most important record because the CEO seeks to portray a corporate image to shareholders on how well the hospital is doing. Accordingly, the complex system records model emphasizes the organizational dynamics within healthcare organizations that a biomedical informatics professional should account for in his or her design of an electronic health records system. Biomedical informatics researchers'

work of finding the best search and representation algorithms to aid in the information retrieval processes but such works miss the social and political dynamics that affect how biomedical institutions operate. Users within these institutions socially construct the realities that they wish to see.

#### **1.4. Thesis Plan**

This thesis is organized as follows. Chapter 2 sets the theoretical context by explaining the complex system records model—this thesis’ main theoretical contribution—and its applications to explain recordkeeping in an organization that manages wicked problems. It also highlights the complex system records model’s theoretical contributions to archival science and biomedical informatics. Chapter 3 provides an overview of this thesis’ methodology and the case—PMI. It begins with an explanation of the rationale of choosing PMI over other organizations in the global malaria regime. It continues by providing an overview of PMI, its role in the global malaria regime, organizational rationale, and its recordkeeping processes. The last part of the chapter explains the choice of the method of interpretive inquiry by focusing on its strengths and weaknesses.

The second part of this thesis—Chapters 4 and 5—provides case studies of how the complex system records model explains PMI’s recordkeeping processes. Chapter 4 focuses on the two most important PMI records: PMI headquarters’ annual report to the U.S. Congress and PMI country offices’ annual reports to PMI headquarters. The author triangulates insights from PMI records with other types of evidence. This chapter explains in details how PMI uses third party entity-created records to create PMI records, and how PMI’s recordkeeping processes sustain an organizational rationale that emphasizes the achievement of targeted performance

benchmarks. Chapter 5 shifts the focus to the epistemology of knowledge that drives PMI's recordkeeping processes. Malaria is an "immunologically challenging infection" and the effectiveness of antimalarial treatment hinges on the appropriate application of antimalarial treatment (Wieten et al. 2011, 102). This chapter shows how PMI's choice of a particular social epistemology of malaria affects its recordkeeping processes. Chapter 6 concludes.

## **Chapter 2 Theory: The Complex System Records Model**

This chapter discusses the complex system records model and its theoretical linkages with works in archival science and biomedical informatics. It begins by explaining the concept of wicked problem by using malaria as an example. Next, section 2.2 explains how recordkeeping in an organization that manages wicked problems differs from an organization that is not managing wicked problems. Section 2.3 then proceeds to describe the complex system records model and explain the linkages with four disciplines: archival science, complexity science, management science, and philosophy. Section 2.4 discusses the complex system records model's contribution to the field of archival science by comparing it with extant models. Section 2.5 discusses the complex system records model's contribution to biomedical informatics by highlighting the interaction between records and the data-hypothesis-theory-knowledge cycle. The section will also highlight how the complex system records model contributes to biomedical informatics in terms of theory and practical applications. Section 2.6 concludes.

### **2.1. Malaria as a Wicked Problem**

Malaria is a global public health problem and it is a wicked problem. As the originators of the concept of wicked problems describe, “wicked problems are messy, ill-defined, more complex than we fully grasp, and open to multiple interpretations based on one’s point of view” (Rittel and Webber 1973, 160). Such problems are intractable and often require transdisciplinary approaches to manage—not solve—the problems. The late prominent psychologist, Professor

Laurence Johnston Peter, nicely captured the essence of wicked problems as follows, “some problems are so complex that you have to be highly intelligent and well-informed just to be undecided about them” (Peter and Hull 1969). An organization that is managing wicked problems is embedded in a complex adaptive system (CAS) where the actors co-evolve with the system via interdependent feedback loops (Buckley 1998, 108-115).

Table 2.1 frames PMI’s antimalarial programs along two axes: the wicked problem-tame problem axis and the transnational-within-nation axis. At the top left quadrant, PMI is managing the wicked problem—malaria—across multiple nations and outside the borders of its home country, the U.S. In addition, PMI is part of the global malaria regime: a complex adaptive system that involves numerous actors with different incentive structures and levels of accountability. PMI is not trying to manage the global malaria epidemic on its own but it narrowly defines its mission as that of reducing malaria burden in PMI focus countries. PMI has to collaborate with third party entities and use their records for PMI recordkeeping.<sup>10</sup> This thesis focuses on the upper left quadrant frame of PMI’s antimalarial programs in Table 2.1.

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<sup>10</sup> Because PMI delegates its antimalarial activities to these third party entities, records are created in the transactions. Examples of such records are the contracts between PMI and the third party entity and the third party entity’s reports to PMI. PMI would often rely on the third party entities’ reports to know the local reality.

Table 2.1. Frames of PMI’s antimalarial programs

		Examples	
		Transnational	Within-nation
Managing wicked problems	Thesis Focus: PMI’s antimalarial programs in PMI focus countries outside U.S.	Tanzanian government’s PMI-sponsored antimalarial projects in Tanzania.	
Managing tame problems	PMI’s vendor ensures that antimalarial drugs reach the right hospitals across PMI focus countries.	Tanzanian health officer in a village ensures that vaccines purchased with PMI funds are administered.	

The remaining three quadrants represent different framings of PMI’s antimalarial programs along the two axes. The upper right quadrant, for instance, frames an actor that is managing a wicked problem within a nation. One example is that of the Tanzanian government managing malaria within its borders by implementing specific PMI-funded antimalarial projects (e.g., distribution of insecticide-treated bed-nets). Both PMI and the Tanzanian government are managing the wicked problem of malaria but differ in geographic scope: PMI manages malaria at the global level in multiple countries while the Tanzanian government manages the wicked problem of malaria that occurs within its borders.

The bottom two quadrants in Table 2.1 frame specific PMI antimalarial programs as the management of “tame problems,” i.e., problems that can be clearly defined and solvable (Rittel and Webber 1973, 160). The lower left quadrant represents that of a third party vendor managing



a tame problem, distribution of antimalarial vaccine to the right hospitals across different PMI focus countries. PMI delegates most of its antimalarial activities to third party vendors hence a third party vendor in this frame solves a well-defined tame problem with a strategy. An example of such a strategy is to find reliable suppliers and transport the antimalarial vaccine to designated hospitals. In the lower right quadrant, PMI's malarial programs can be framed as one where PMI's partner, the Tanzanian Government, implements a specific PMI-sponsored antimalarial program. One example is that of a Tanzanian Government health officer in a village who ensures that the antimalarial vaccines purchased with PMI funds are administered to malaria patients. His or her act of applying the appropriate antimalarial vaccines is the act of solving a tame problem.

## **2.2. The Impact of Wicked Problems on Recordkeeping**

Recordkeeping in an organization that manages wicked problems differs from recordkeeping in an organization that manages a tame problem. Recordkeeping, according to the Society of American Archivists' (SAA) *Glossary of Archival and Records Terminology*, is "the systematic creation, use, maintenance, and disposition of records to meet administrative, programmatic, legal, and financial needs and responsibilities" (Pearce-Moses 2005). A record is "a written or printed work of a legal or official nature that may be used as evidence or proof; a document" (ibid.). In other words, records serve to make an organization accountable, trustworthy, and facilitate coordination within an organization and with other organizations. Accordingly, the "contextuality" of a record matters because the creators of the information and data can be held accountable for the accuracy of the record (Bearman 1994; Cook 1997, 23-24). In addition, an organization produces data (e.g., the amount of vaccine that PMI purchased for the last work year) and documents (e.g., letter of invitation for a PMI-organized malaria symposium). Data

and documents then become records when “the content, context, and structure are tied together to provide both meaning and functionality” (McGovern and Samuels 1998, 104).

Recordkeeping processes between an organization that manages wicked problems and an organization that manages a tame problem differ in three ways. First, wicked problems are intractable with ill-defined boundaries and are intricately bounded with other problems. Works in the management science literature are based on the fundamental premise that an organization’s operations are geared towards achieving its mission. Recordkeeping, therefore enables an organization to be accountable and trustworthy, and to facilitate intra-organization coordination.<sup>11</sup> In contrast, recordkeeping in an organization that manages wicked problems differs from a typical organization that manages a tame problem. The structure and content of the record that were created yesterday would no longer adequately describe the organization’s current activities. For instance, if the antimalarial vaccine that PMI used in the past has become ineffective, PMI would have to change its antimalarial programs by either purchasing new types of vaccines and/or use a non-vaccine approaches. The context of the records related to wicked problems therefore changes according to evolving circumstances.

The second key difference is that stakeholders of an organization that is dealing with wicked problem have different framings of the wicked problem and different perceptions of the most appropriate strategy to manage the wicked problem. This discrepancy in perception affects its recordkeeping because different stakeholders have differing ideas of what should be included in the records. Accordingly, the records *inevitably* present a simplified picture of the complex

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<sup>11</sup> The rationale to devise a framework to tailor recordkeeping frameworks to match an organization’s business operations has been operationalized by the InterPARES (International Research on Permanent Authentic Records in Electronic Systems). InterPARES’ business-driven recordkeeping model is based on the National Institute of Standards and Technology (NIST)’s IDEF0 Function Modeling Method. This recordkeeping model details the flow of record/information between different business operations within an organization and the crossing of departmental boundaries. For a good overview of InterPARES, see Duranti (2007).

wicked problem because actors choose among competing evidences to include in the records. This idea ties in well with the recognition in the archival science literature that records are not neutral and are related to the power dynamics within the organization (Cook and Schwartz 2002, 9, 13; Schwartz and Cook 2002). At the macro-level, organizations have the incentives to create records that portray their desired organizational reality rather than the actual operations that were carried out (Trace 2002). Furthermore, at the micro-level, the interpretation of a record varies with the person using it because the record was “created by persons or devices that participated in or observed the represented activity or by persons authorized to act as their proxies” (Yeo 2007, 337).

Third, accountability mechanisms vary among the actors who are managing wicked problems. In the context of PMI, there are two types of vertical accountability mechanisms: PMI-U.S. Congress and PMI-third party entities (e.g., third party vendors and PMI focus country governments). For the former, PMI is accountable to the U.S. Congress because PMI’s antimalarial efforts are part of the U.S. government’s foreign policy goal of reducing global public health problems.<sup>12</sup> For the latter, PMI’s third party vendors, for instance, receive PMI funds for implementing PMI’s antimalarial projects hence they are accountable to PMI. Besides vertical accountability, there is horizontal accountability between PMI and the actors in the global malaria regime (e.g., WHO). PMI works closely with these actors in different projects hence PMI is accountable to them. These accountability mechanisms may however crosscut each other in the context of PMI’s antimalarial programs. PMI’s antimalarial mission, for instance, serves primarily the U.S. government’s foreign policy hence its accountability to the U.S. Government could contradict PMI’s accountability towards its partners in the global malaria

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<sup>12</sup> PMI was started in 2005 under the Bush administration and received a boost under the first Obama administration’s Global Health Initiative (GHI).

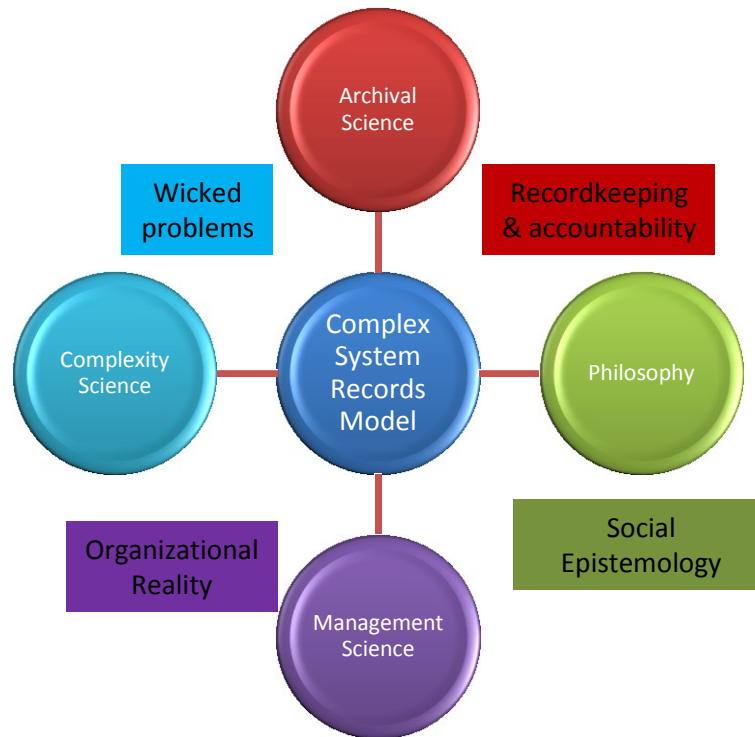
regime. The cross-cutting of accountability mechanisms could politicize PMI's recordkeeping processes.

## **2.3. The Complex System Records Model**

### ***2.3.1 The Complex System Records Model in Detail***

The complex system records model's theoretical foundation centers on the theories and concepts from four disciplines: archival science, complexity science, management science, and philosophy (Figure 2.1). First, the complex system records model focuses on recordkeeping within an organization that manages a wicked problem hence it draws insights from the archival science literature on the dynamics of records and recordkeeping (Cook forthcoming). Second, the theoretical insights from complexity science are also incorporated into the complex system records model, especially the concepts of complex adaptive systems, wicked problems, and emergence (Mitleton-Kelly 2003; Thrift 1999). Third, because recordkeeping occurs in an organizational context, the complex system records model builds on management science's theoretical insights on organizational development and organizational learning (Weick 1969, 1995). Finally, the epistemology of knowledge that an individual embraces affect the nature of information that the organization's staff member enters into records hence the complex system records model builds upon the theoretical insights of social constructivism in philosophy. The complex system records model adopts the perspective that ontology and epistemology are socially constructed, hence the social ontology and social epistemology of knowledge that an organization subscribes to would in turn affect its recordkeeping.

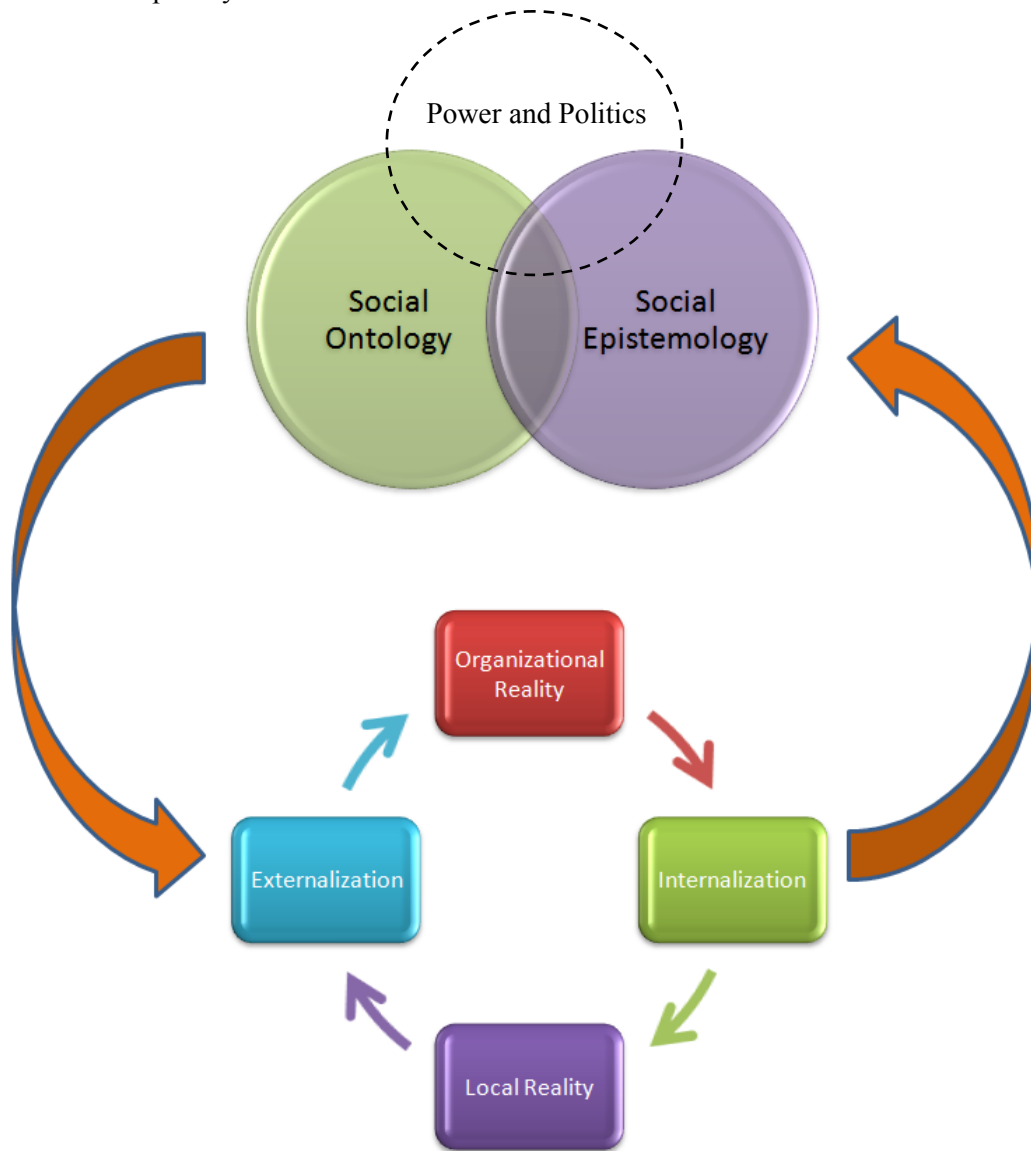
Figure 2.1. The complex system records model's theoretical foundations



The complex system records model centers on the political and socio-cognitive processes that motivate intra-organization actors to acquire, create, and/or process the meaning of the records collectively as a group (Akgün et al. 2003). An organization's staff members at the bottom of the power hierarchy observe the reality on the ground—local reality (Figure 2.2). For example, different staff members working in the same organization and collecting data in a small village would perceive the local reality differently. This reality is “interpreted” as a “coherent world” in a way that is “subjectively meaningful” to these members (Berger and Luckmann 1966, 19). The crux of the social construction of local realities is that these different groups of staff members *believe* that the local reality exists and therefore act as though this reality exists. Anthropologists Bruno Latour and Steve Woolgar argue that “we do not wish to say that facts do not exist nor that there is no such thing as reality....but our point is that ‘out there ness’ is a consequence of scientific work rather than its cause” (Latour and Woolgar 1979, 180-182). The

complexity of malaria—a wicked problem—increases the level of uncertainty and staff members who are working in the local environment therefore face tough challenges to accurately capture the true reality.

Figure 2.2. The complex system records model



Notes:

[1] The complex system records model has two main parts: the top part deals with the interaction between social ontology and social epistemology of knowledge that an organization embraces and the bottom part deals with the organization's recordkeeping processes.

[2] Adapted from Berger and Luckmann (1966), Gjersvik (1993) and Weick (1969, 1995). These works explain organizational dynamics from sociological and management science perspectives. The author has adapted their ideas to explain recordkeeping within an organization that manages wicked problems.

These socially constructed multiple local realities are in turn externalized via the actions of the organization's staff members (Figure 2.2). These actions can be in the form of formal (e.g., standard operating procedures) and informal (e.g., daily conversations between employees) processes. The externalization process produces records that capture a snapshot of the local reality as perceived by the staff on the ground. Individuals who view these records—as works in hermeneutics have shown—would have different interpretations and understanding of the *same* records that they read.<sup>13</sup> In short, the “many contingencies which are affecting official work, offering options for conscious choice, may not appear in the records because recording reduces the scope of possibilities to one voice” (Craig 2002, 136). Each individual has a different “horizon” (or perspective) of each data and document, and the interactions between individuals collectively lead to another layer of social construction of local reality (Guba and Lincoln 1994, 109; Klein and Lyytinen 1992, 214-216). The complex system records model also explains the nature of the knowledge that affects recordkeeping, i.e., social ontology and social epistemology, and this will be discussed in depth in the next section.

An organization is fundamentally about “control and order” and recordkeeping becomes a mean for an organization to portray an organizational reality; thereby enabling the organization to “perpetuate itself and its rights” (Craig 2002, 114; Schwartz and Cook 2002, 14). Accordingly, an organization is a “negotiated order” where actors within the organization engage in continuous renegotiation in their everyday work (Strauss et al. 1963). These forms of externalization become multiple socially constructed organizational realities (Berger and Luckmann 1966, 60-61; Dahlbom 1992, 108-110). Only one dominant organizational reality would eventually be legitimized and internalized as the dominant organizational norms and

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<sup>13</sup> For archival science works that adopt ideas from hermeneutics, see Lövblad (2003) and Trace (2002; 2010).

beliefs (Frost 1991; Frost et al. 1985; Mumby 1987; Pondy et al. 1983). The last two steps of the construction of organizational reality and internalization usually involve some degree of politicization. There are competing constructions of reality (or dominant narratives) and the selected constructions of reality are usually the ones that are favored by the powerful actor or group. Furthermore, at the individual level, staff members of the organization “simultaneously externalize” their social selves into the organization and “internalize” the organization reality as an “objective reality (Berger and Luckmann 1966, 128). With the dual internalization processes occurring at the organizational level and at the staff member level, the organizational reality is reinforced when the staff members do their work by capturing snapshots of the local reality. Their internalization of organizational reality creates a mental model that becomes a cognitive filter that reinforces what they assess to be important enough to be included in the record. As a result, an organization becomes “a network of inter-subjectively shared meanings that are sustained through the development of a common language and everyday social interaction” (Walsh and Ungson 1991, 60).

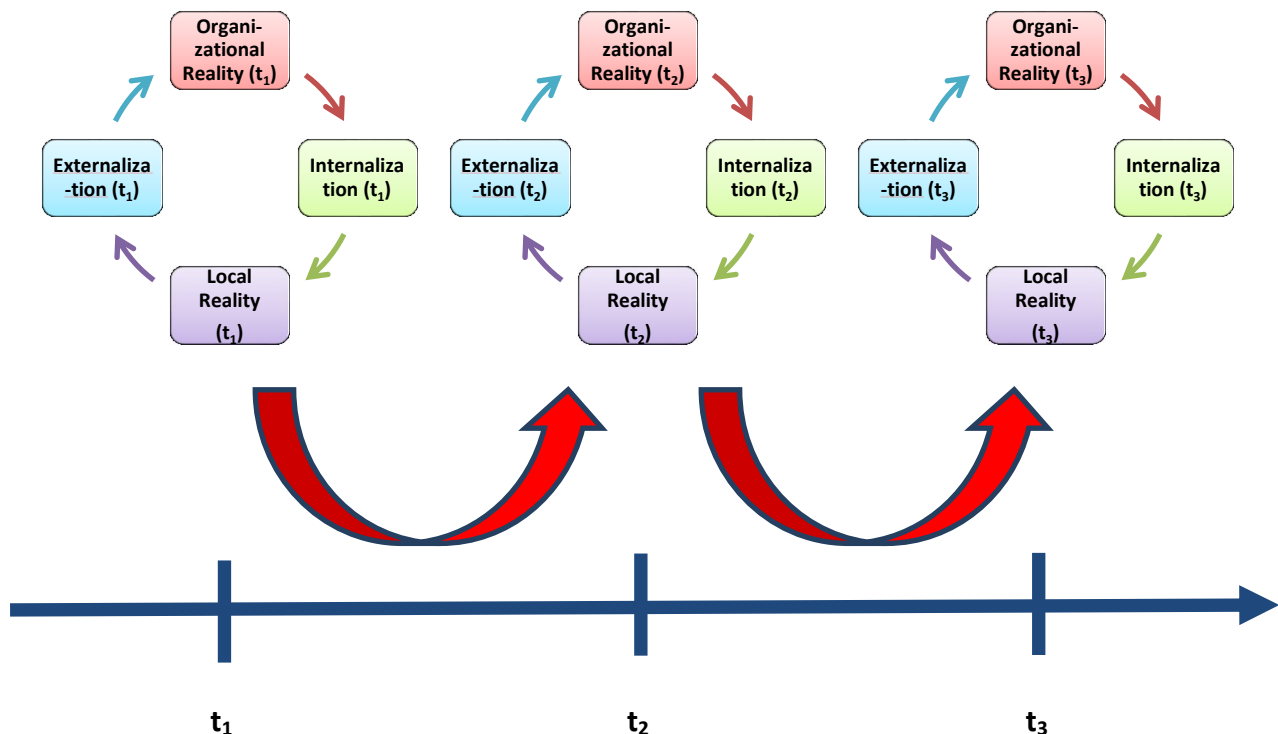
To re-emphasize, the framing of the role of recordkeeping is the most important aspect of these processes of social construction of organizational reality within the complex system records model. The complex system records model states that records in an organization are manifestations of this interaction between renegotiations and work processes. Recordkeeping in turn affects how members of an organization view the organization, their management, their colleagues, and their own roles within the organization. Records codify and aid the internalization of norms within organizations. This process in turn embeds the dominant organizational reality. Accordingly, formal and informal groups within organizations affect the type of records that are created while the process of social construction reality within



organizations affects how staff members within organizations choose the types of data/information/documents to incorporate as part of a record.

The complex system records model is not a cyclic process where the cycle starts from local reality, ends with internalization, and then re-starts again from local reality. The process is more complex and it is shown in Figure 2.3. In time  $t_1$ , there is a particular local reality, process of externalization, organizational reality, and process of internalization. As time proceeds to time  $t_2$ , there is a different local reality, process of externalization, organizational reality, and process of internalization within the *same* organization; the cycle repeats in time  $t_3$ . During each period, each component of the complex system records model may change at a different rate and in multiple dimensions. Suppose the organization has three competing groups that are involved in intense politicking, each of these groups may prefer different organizational reality to prevail within the organization in different periods.

Figure 2.3. Evolution of the complex system records model across time



### ***2.3.2 The Effect of Scientific Knowledge on Recordkeeping***

Records are usually created by an organization's staff members who have in-depth subject matter knowledge but archival science scholarly works offer few insights on how the type of knowledge that an organization embraces would affect its recordkeeping. Knowledge that is associated with wicked problems, for instance, is more complex because there is no consensus on what the crux of the problem is and how actors should collaborate in order to manage the problem. Actors, therefore have to *choose* among competing paradigms and theories in order to create their records. Philosophical debates about scientific inquiry focus on the non-objective (non-realist) aspects and social constructivist scholars, in particular, argue that scientific knowledge is socially constructed. These scholars argue that paradigm change in scientific disciplines rarely occurs due to new theories but occurs when the supporters of the old theories gradually lose their influence over the science disciplines (Kuhn 1962; Midgley 1994; Planck and Johnston 1936).

An emerging group of works in the field of biomedical informatics focuses on the interaction between data, information, and knowledge (Bernstam et al. 2010). Theories thereby become important because they are abstractions of reality and provide a focal point for intellectual development (Brennan 2008). The complex system records model contributes to this group of biomedical informatics works by focusing on the socio-psychological and philosophical aspects of scientific inquiry. There are three basic fundamental beliefs in scientific inquiry: ontology, epistemology, and methodology. In the words of Guba and Lincoln (1994, 108):

- The ontological question aims to tease out: what is the form and nature of reality and, therefore, what is there that can be known about it?
- The epistemological question aims to tease out: what is the nature of the relationship between the knower or would-be knower and what can be known?

- The methodology question aims to tease out: how can the inquirer go about finding out whatever he or she believes can be known?

The complex system records model draws from the social constructivist approaches by focusing on “ontological relativism” (ibid., 109). Social ontology is about what actors perceive in the world that is for them to know and it is a result of their acts of social construction (Searle 2006). Social epistemology is “a state of affairs that will only be taken to be evidence that something else is the case in light of some background belief or assumption asserting a connection between the two” (Longino 1990, 44; 2002). As shown in Figure 2.2, social ontology and social epistemology are mutually reinforcing. Pockets of “communities of knowing” create norms that delineate the boundaries that define academic standards and procedures (Amin and Roberts 2008; Boland and Tenkasi 1995, 351). There are “procedures that are regarded as appropriate...acceptable in that paradigm, and...in a particular subject” (Biggs and Buchler 2008). Accordingly, the different communities of knowing are the epistemic communities that deal with antimalarial research and these communities in turn codify the acceptable norms and state of knowledge (Creplet et al. 2001).

This thesis has strong intellectual connections with actor-network theory (ANT) that states that the social construction of knowledge occurs among different actor-networks (Callon et al. 1986; Dolwick 2009; Latour 2005). One key premise of actor network theory is that “it [the uncertainty principle] remains impossible to decide whether it resides in the observer or the phenomenon being observed... it’s never the case that the analyst knows what the actors ignore, nor is it the case that the actors know what the observer ignores” (Latour 2005, 22).

The evolution of antimalarial research illustrates the importance of social ontology and social epistemology of scientific knowledge on malaria and antimalarial measures. The social

epistemology of malaria is closely connected because appropriate antimalarial measures can only be implemented when policy makers understand how malaria is transmitted. Before the 1850s, the social epistemology of the causes and transmission of malaria was that of humans consuming swamp water (Cormier 2011; Sherman 2011, 4-21). In the 1880s, the social epistemology that gained credence was that of malaria transmission via malaria parasites; in the 1890s, *Anopheles* was widely accepted as the transmitter of malaria; and in the mid-1940s, scientists accepted that malaria parasites multiply in the human liver (ibid.). Consequently, the social epistemology of antimalarial measures also co-evolved with the social epistemology of malaria transmission. One common antimalarial measure is the application of antimalarial vaccine. Quinine was the first natural antimalarial drug and became available as early as three hundred years ago. It was only in the 1930s that the first synthetic antimalarial drug was developed, and this was followed by the development of Atabrine, Chloroquine, and then antibiotics in the last fifty years (Sherman 2011). The co-evolution of the social epistemology of malaria and antimalarial measures affected how organizations managed malaria. In the period from 1950s to 1970s, the “best practices” of antimalarial measures centered on the use of DDT indoor residual spraying but the vectors’ increased resistance to pesticides and antimalarial drugs made this treatment less effective (ibid.). Since the 1970s, the “best practice” shifted from indoor residual spraying to antimalarial treatment but this led to another set of problems; the vectors developed resistance against chloroquine (ibid.). Malaria vectors continue to develop resistance to new antimalarial drugs despite the huge investment in antimalarial research (Phyo et al. 2012).

In short, the implications of the evolving social epistemology of knowledge on malaria and antimalarial measures affect recordkeeping in an organization that manages malaria. Staff members who are working in the organization would embrace this social epistemology and fill in

the details of the records that bias towards the social epistemology of malaria. Records, therefore, externalize this organizational bias, and perpetuate an organizational reality.

## **2.4. Contribution to Archival Science**

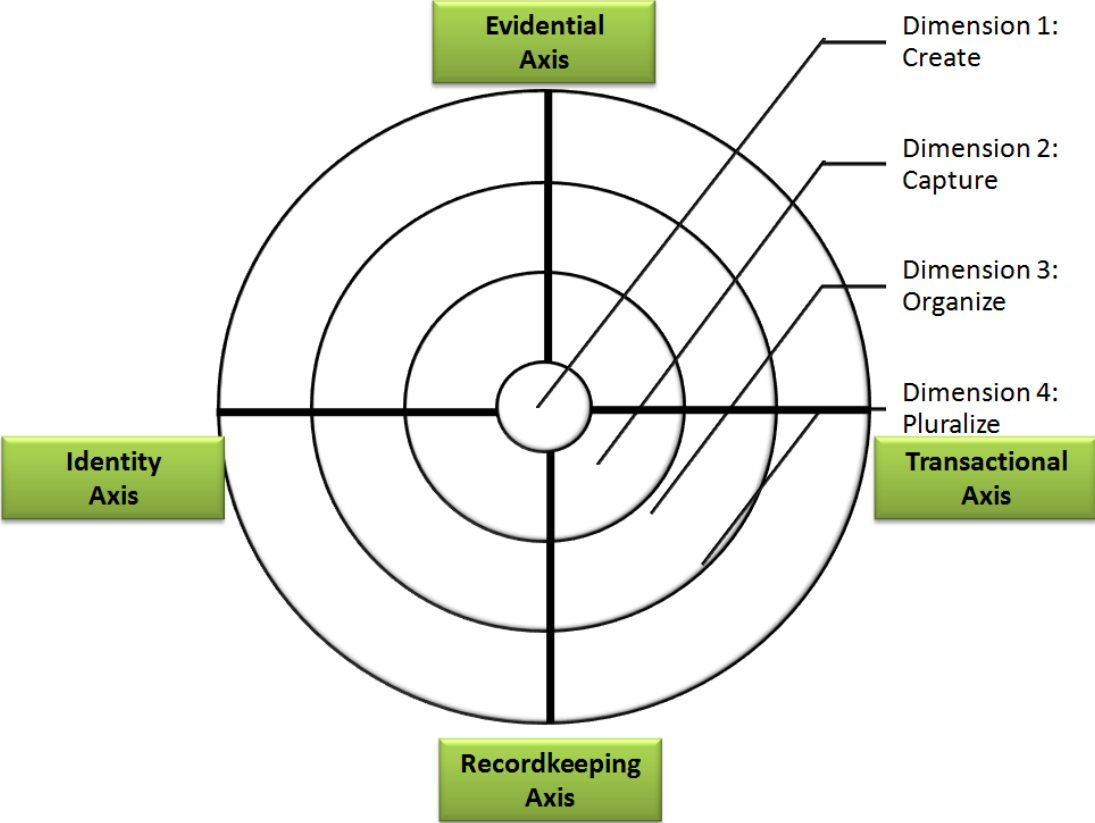
This thesis contributes a complexity science perspective of recordkeeping to archival science as it enters the fourth “archival paradigm” of “postmodern archiving,” (Cook forthcoming). To re-emphasize, the complex system records model is complementary to existing conceptual models of recordkeeping and this thesis’ main contribution is to present an alternative conceptual model to explain recordkeeping in an organization that manages a wicked problem.

### ***2.4.1 Extant Model 1: The Records Continuum Model***

This thesis’ theoretical contribution is to propose an alternative model to the records continuum model (McKemmish et al. 2010; Reed 2005; Upward 1996, 1997, 2000). The records continuum model cannot adequately explain recordkeeping processes within an organization that manages wicked problems. There are four dimensions in the records continuum model—create, capture, organize, and pluralize—along four axes—evidential, transactional, recordkeeping, and identity (Figure 2.4). Beginning from dimension 1, a document—*not* a record—is created and this document becomes “captured” (dimension 2) and becomes a record. The records are “organized” (dimension 3) to become records that would be archived; and finally the records are “pluralized” (dimension 4) across different contexts. The four axes represent the “multiple realities” that individuals face in recordkeeping: evidence, transactions, recordkeeping, and identity create additional dimensions (Upward 1997). Staff members in an organization often use records for the

purpose of recordkeeping and evidence. Organizations also use records in daily transactions and these acts of carrying out transactions reinforce their organizational reality.

Figure 2.4. The records continuum model



Note: Adapted from Upward (1996)

There are three main differences in the conceptualization of records between the complex system records model and the records continuum model (Table 2.2).

Table 2.2. Comparison of the complex system records model and the records continuum model

	Complex system records model	Records continuum model
<i>Hierarchy of records</i>	Records are not created equal: <ul style="list-style-type: none"> <li>• simple-complex</li> <li>• more important-less important</li> </ul>	Not explicitly mentioned.
<i>Function of records</i>	The relatively more important records function as attractors reinforces organizational reality.	Records are framed in terms of four dimensions (create, capture, organize, and pluralize) and four axes (evidentiality, transactionality, recordkeeping, identity).
<i>Usage of records</i>	Records depend on the information extracted from records created by other organizations (e.g., third party vendors and governments of PMI focus countries).	The building, recalling and dissemination records in the “organize” and “pluralize” dimensions (Upward 1996, 280-281).

### ***Hierarchy of records***

The first difference is that the complex system records model states that records are not created equal, i.e., records can differ from each other in terms of their level simplicity (simple-complex) and importance (more important-less important).

In terms of the level of simplicity, a simple record is a type of records that is created by a pre-determined set of organizational rules and procedures. One example is a set of standard operating procedures for processing inventory records. The clerk creates a record that details the receipt of goods from a deliveryman (e.g., time and quantity). Another type of records is the more complex records because human judgment is needed to present the relevant information in a complex record. One example of a complex record is meeting minutes. The minute-taker must accurately capture the essence of the key decisions and rationale of the meeting and his supervisor would in turn approve the minutes. There is therefore a degree of filtering of the

information from the meeting and the nature of the filtering depends on the cognitive models of the minute taker and his supervisor.

Next, in terms of a record's level of importance to an organization's function, a less important type record includes inventory records and human resource records. To be clear, these types of less important records are certainly essential for an organization's functioning and accountability but they are less important—in this thesis' context—as compared with the relatively more important record such as the company's annual report to its shareholders. A company's annual report to its shareholders, for instance, is relatively more important than the company CEO's official email because the former is a form of accountability to shareholders and perpetuates an organizational reality that the CEO and the management wish to portray to the shareholders, customers, and employees.

### ***Function of records***

As shown in Table 2.2, the complex system records model also differs from the records continuum model in the framing of the function of records. Extending from the concept of the hierarchy of records, the complex system records model states that the relatively more important records within an organization are “attractors” that perpetuate an organizational reality. The concept of attractors originates from complexity science and the idea is that attractors are entities within a complex adaptive system that play an important role—similar to the concept of center of gravity—in affecting the evolution of an ecosystem (Mackenzie 2005). One example of a record that acts as an attractor is an annual report that documents the organization's achievements and future plans. In contrast, the records continuum model presents multiple perspectives of records



along four dimensions (create, capture, organize, and pluralize) and four axes (evidentiality, transactionality, recordkeeping, identity).

### ***Usage of records***

The third difference is that the complex system records model states that an organization that manages wicked problem depends on third party-created records to create their own records. The records continuum model, in contrast, is not explicit on the jurisdictional boundaries and does not focus on the origins of these records. This distinction is important because records capture snapshots of multiple local realities. In a hospital context, for instance, a medical record captures the reality of a patient's medical condition. In the context of malaria, PMI does not have adequate human resources to station in each of the localities that have malaria problems. Accordingly, PMI has to delegate its antimalarial activities to third party vendors and these vendors in turn generate records (e.g., reports) that capture the multiple local realities. PMI, therefore relies on third party-created records to capture snapshots of the local realities of malaria.

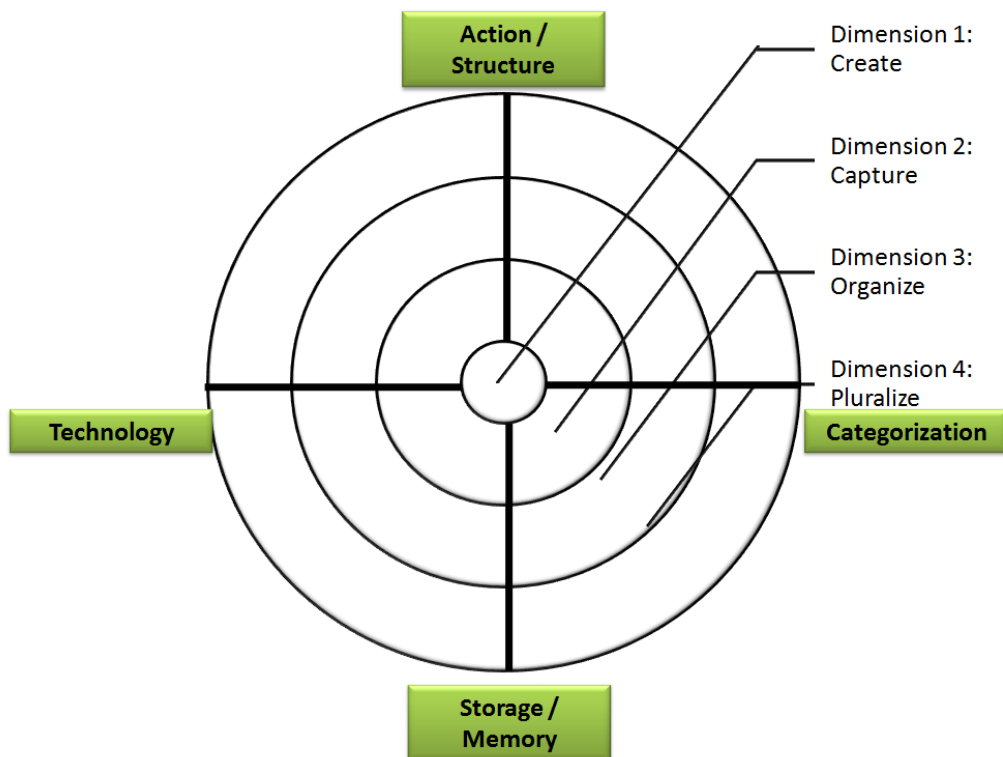
### ***2.4.2 Extant Models 2: The life cycle model, the information continuum model, and the meta-synthetic support framework***

The complex system records model also complements insights from three groups of works: the life cycle model, the continuum approach, and the knowledge management approach. The first group of works uses the life cycle model that depicts that a record goes through a cycle that begins with its creation, followed by its storage, and this record is ultimately either archived or disposed at the end of its life cycle (Schellenberg 1956; Shepherd and Yeo 2003). The complex system records model differs from the life cycle model by focusing on the organizational

dynamics that contextualize recordkeeping within an organization. The complex system records model's key focus is *how* records are used to perpetuate the organizational reality.

The second group of works extends from the records continuum model by using the continuum concept to model the flow of information within organizations (Oliver 2010; Schauder 2005; Upward 2000). The key objects of interest in the information continuum model are information *and* records. Similar to the records continuum model, the information continuum model has the same four dimensions but four different axes (Figure 2.5).<sup>14</sup>

Figure 2.5. The information continuum model



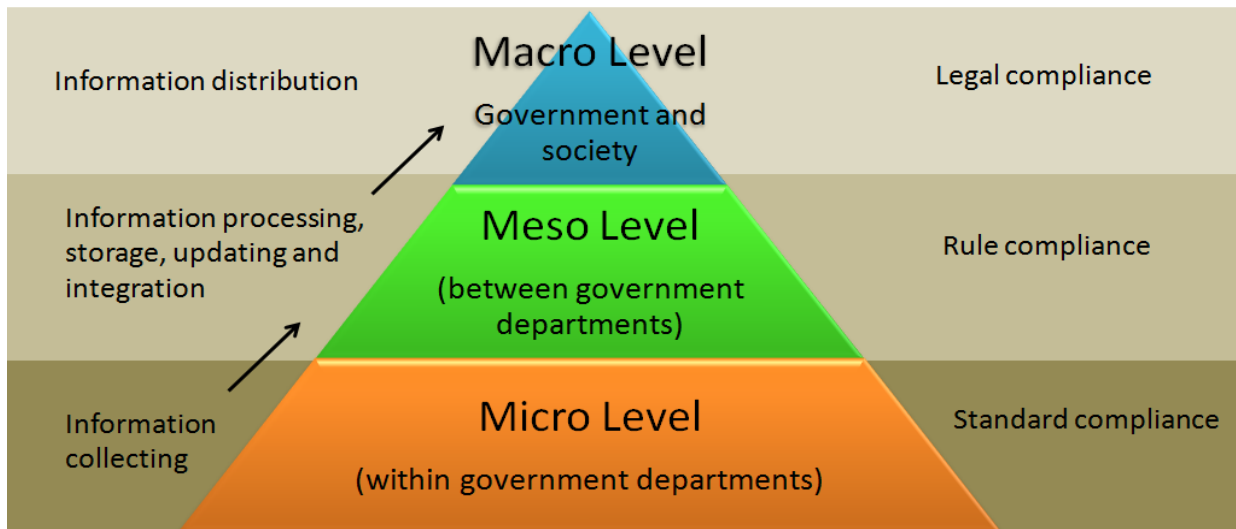
Note: Adapted from Upward (2000), 130. The four axes differ from the records continuum model while the four dimensions are the same.

<sup>14</sup> The information/records within an organization are categorized (first axis), the actions of the organization staff members are affected by the organizational structure and vice versa (second axis), the technology within the organization enables staff members to manage information/records within the organization (third axis), and the information/records are stored in various forms of the staff members' collective memories (fourth axis) (Upward 2000, 130).

The strength of the information continuum model is that it provides a framework to link records and information within the context of organizational development. Nevertheless, its main weakness is that it does not clearly differentiate between records and information. These are two different sets of “commodities” within an organization that perform different roles. Information is “a collection of data and associated explanations, interpretations, and other textual material concerning a particular object, event, or process” (Bergeron 2002, 9). In contrast, the textual material that a staff uses as information can be a record which has the main purpose of providing evidence of organizational transactions. In short, these two commodities are fundamentally different and serve the organization differently: information is used to enable the organization to perform transactions while a record is used as the evidential basis for an organization to be held accountable to its stakeholders.

The third group of works combines insights from knowledge management and e-government and puts forth the meta-synthetic support framework (An et al. 2012). The complex system records model and the meta-synthetic support framework have the commonality of understanding recordkeeping within organizations that handles complex problems. The meta-synthetic support framework seeks to explain the broader issue of the interaction between data, information, records, and knowledge within the contexts of a government and society (Figure 2.6). The model frames the data/information/records/knowledge flow within each government department (micro level), between government departments (meso level), and between government and society (macro level). The most important process at each of these levels (micro, meso, and macro) is standard compliance, rule compliance, and legal compliance respectively.

Figure 2.6. Meta-synthetic support framework



Note: Adapted from An et al. (2012), 13

The complex system records model differs from the meta-synthetic support framework in terms of the object of interest. The complex system records model uses *only* records as the object of interest while the meta-synthetic support framework has four objects of interest: data, information, records, and knowledge. The complex system records model states that an organization uses records for the perpetuation of an organizational reality whereas the meta-synthetic support framework states that an organization uses data, information, records, or knowledge as part of its daily transactions.

While both the complex system records model and the meta-synthetic support framework are complementary, the complex system records model differs fundamentally from the meta-synthetic support framework. The complex system records model emphasizes the social construction of local realities and organizational realities whereas the meta-synthetic support

framework implicitly assumes that there is a “true” phenomenon out there that the data, information, records, and knowledge can capture. The complex system records model’s key driver is how individuals within organization—especially the management—legitimizes at least one of the multiple realities whereas the meta-synthetic support framework’s key driver is the deliberate process of systematizing the multiple management of data, information, records, and knowledge according to various International Organization for Standards (ISO) standards. Both the complex system records model and the meta-synthetic support framework could certainly be applied to organizations that manage wicked problems but the complex system records model better captures the crux of the challenge of wicked problem management: the co-evolution of the organization that is managing the wicked problem, its collaborators/third party entities, and the wicked problem. The meta-synthetic support framework, in contrast, is static and implicitly assumes that a wicked problem can be “problematized” and solved.

## **2.5. Contribution to Biomedical Informatics**

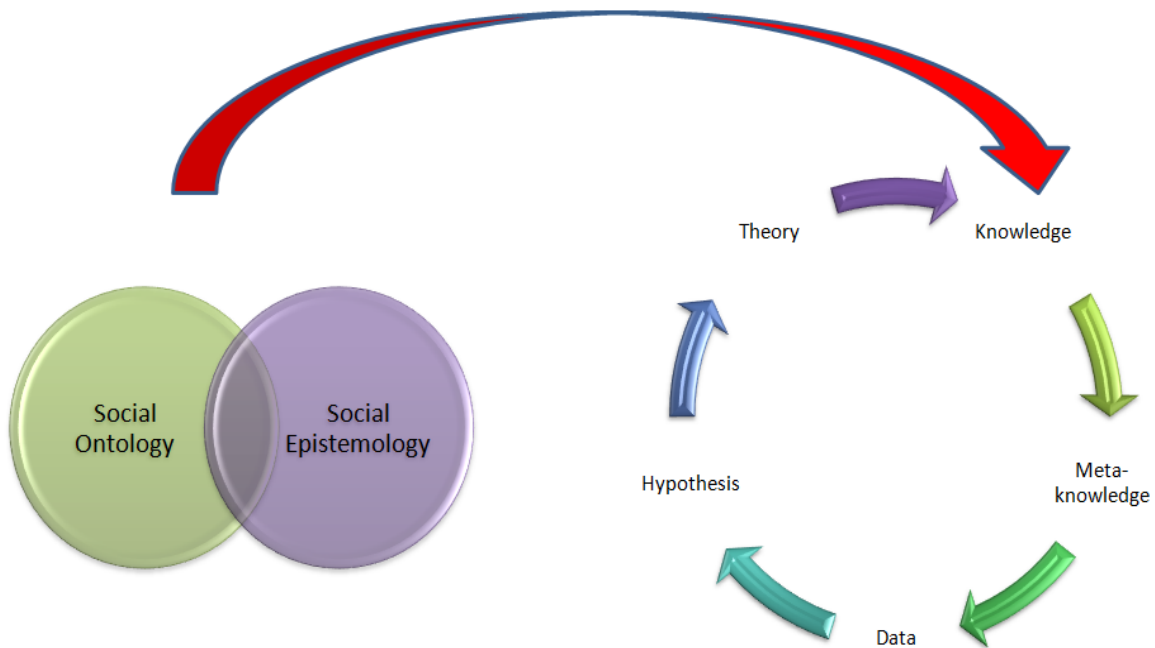
There is a growing recognition in the field of biomedical informatics of the importance of theories (Brennan 2008). The complex system records model advances these theoretical discussions by addressing two main gaps in biomedical informatics. The first theoretical gap is the lack of focus on the nature of scientific inquiry. Extant biomedical informatics works adopt ontological realism where biomedical informatics researchers and practitioners assume that there is a true world out there for them to investigate. Consequently, biomedical informatics research centers on the data-hypothesis-theory-knowledge-metaknowledge framework where the researcher collects the data to validate his or her hypothesis (e.g., Evans and Foster 2011, 721).

This thesis argues that there is no ontological realism in scientific inquiry and uses the complex system records model to bring to the forefront the social construction of the ontology and the epistemology of scientific knowledge. As Figure 2.7 shows, the social ontology and social epistemology that a scientific community chooses would affect the knowledge that they seek and this in turn affects their mode of scientific inquiry, i.e., using data to validate the knowledge. Biomedical informatics is a mode 2 knowledge production that involves the production of knowledge that is “context driven” and trans-disciplinary (Gibbons et al. 1994). Accordingly, scientists consciously or subconsciously embrace a knowledge that is linked to a particular social ontology and social epistemology that affect their mode of scientific inquiry. Actors *choose* from the scientific data and interpretations of data (e.g., theories) to represent in records. Scientists working in the same laboratory may interpret the data in the records differently and their final consensus on the best interpretation of data usually involves the social processes of negotiations.<sup>15</sup>

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<sup>15</sup> Annemarie Mol (2002), for instance, examines how an illness is socially constructed in hospitals and not merely a purely objective diagnosis. Similarly, in this thesis’ context, the enterprise of understanding how malaria spreads and how antimalarial interventions work is largely a social process that occurs within and between different communities. Heinz Klein and Kalle Lyytinen (1992) argue that actors bring with them different mental models and this difference in turn affects the way they interpret the *same* data. This process operates in the global antimalarial regime because health workers in the villages and USAID health workers may have different interpretations of the same aggregate malaria data of a region because of their differing mental models. Social processes, therefore, occur to enable them create a *shared* interpretation of the *same* data.

Figure 2.7. The cycle of data, hypothesis, theory, knowledge, and metaknowledge



The next theoretical gap in biomedical informatics is the lack of focus on records. Accordingly, the complex system records model ameliorates this theoretical gap by differentiating between records and data. Records are the evidences of an organization's work outputs and an organization uses records as the main way to show its accountability to its stakeholders. One biomedical informatics sub-field, health informatics, focuses on the development of information systems that cater to either a single healthcare provider and/multiple healthcare providers. These systems are mainly interested in the information that is stored in records. For example, the system is interested in enabling easy retrieval of data from individual medical records (e.g., age, gender, disease type, medication history). Another type of hospital records are the financial transactions associated with wide variety of activities that ranges from

patient bill payments to procurement of medications. In short, this thesis' complex system records model focuses on *why* records are created and *why* recordkeeping is conducted in a specific way; this research orientation differs greatly from extant biomedical informatics studies that seek to design systems that allow users to access relevant information in the hospital records.

The complex system records model differentiates records based on their levels of importance (see Table 2.2). Important records are often the attractors of the organization because they affect the organizational identity. Accordingly, a hospital's annual report to its stakeholders is an important record because it functions as an attractor to shape its organizational identity. The hospital leadership has a large say in the composition of this record because this record—the annual report—is a form of accountability to the hospital stakeholders; the hospital leadership frames the record in a way that creates a the corporate image that the leaderships aims to portray. Consequently, extant works on health informatics—a subfield within biomedical informatics—ignore the complexity and context of records within organizations. The Contextual Implementation Model (CIM) is one such design of health information system that emphasizes context (Callen et al. 2008). CIM accounts for organizational context, clinical unit or departmental context, and the individual context of information flow within an healthcare organization (Figure 2.8). This model is adequate in explaining the “what” of the information that is embedded in the hospital records but is less able to explain the “why” of recordkeeping. The complex system records model focuses on the linkage between recordkeeping and organizational identity. The model states that records are the key mechanisms where important organizational decisions and transactions are recorded, and where the organization is held accountable.



Figure 2.8. Contextual implementation model



Note: Adapted from Callen et al. (2008)

## 2.6. Conclusion

The complex system records model complements the records continuum model. This thesis draws from four disciplines: archival science, complexity science, management science, and philosophy. This thesis builds from the perspective of the importance of records as a form of accountability in the archival science literature. From the complexity science literature, this thesis shows the nature of the wicked problem that PMI seeks to manage. From the management science literature, this thesis shows how organizations manage wicked problem and how it translates local reality into organizational reality. Finally, from the field of philosophy, this thesis shows how PMI chooses a particular social epistemology of malaria transmission and antimalarial interventions. As Chapters 4 and 5 will show, the complex system records model is able to explain recordkeeping in an organization that manages wicked problem across multiple

nations; PMI conducts antimalarial activities by delegating them to the local governments and non-profit organizations. PMI uses records created by these agencies to construct its organizational reality and this is internalized within PMI.

## Chapter 3 Case Selection and Methodology

The U.S. Government is one of the most important actors in the global malaria regime that includes actors such as international organizations (e.g., WHO and the World Bank), philanthropic organizations (e.g., the Bill and Melinda Gates Foundation), governments, and other entities (e.g., the Research Triangle Institute).<sup>16</sup> This thesis uses PMI as a case to illustrate the explanatory power of the complex system records model. Section 3.1 begins with an explanation of the choice of PMI over other U.S. and global antimalarial organizations. Next, section 3.2 provides an overview of PMI's recordkeeping processes. Section 3.3 explains the rationale and the steps for carrying out the method of interpretive inquiry, and section 3.4 concludes.

### 3.1. Rationale for Choosing PMI

This thesis chooses PMI because it best fits three case selection criteria. First, the organization of interest must only deal with the wicked problem of malaria. This thesis chooses malaria because it is one of the more challenging wicked problems in global public health.<sup>17</sup> Malaria has plagued humanity for at least ten thousand years and it is a result of the co-evolution of the host (humans), vectors (mosquitoes), and parasites (numerous strains of malaria parasites) (Cormier 2011, 9-

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<sup>16</sup> The U.S. Government via its Global Health Initiative (GHI) is using PMI as the lead agency in its global antimalarial efforts. The other two global efforts are the WHO-led Multilateral Initiative on Malaria (MIM) and the Bill and Melinda Gates Foundation-led Malaria Eradication Research Agenda (MaIERA).

<sup>17</sup> UN has identified eight wicked problems in its Millennium Development Goals (MDGs), AERI has identified nine grand challenges, while Jean-Francois Rischard listed twenty global problems in his book, *High Noon* (Gilliland and McKemmish 2012; Rischard 2002).

13).<sup>18</sup> Accordingly, PMI is chosen because its mission is to reduce the malaria burden in selected countries outside the U.S. Large international organizations in the global malaria regime (e.g., WHO) are not appropriate cases because they are simultaneously handling multiple wicked problems. This in turn creates a methodological problem of identification because it is difficult to identify if a WHO record, for instance, is serving the needs of WHO's antimalarial efforts or its broader efforts to manage multiple wicked problems. PMI, in contrast, only manages one wicked problem hence PMI records can be inferred as serving only its antimalarial goals.

Second, PMI is an U.S. government agency that is funded solely by the U.S. Government hence PMI's recordkeeping is accountable to the U.S. Government. In contrast, an international organization such as WHO is funded by member states' contributions and it has to be accountable to UN and its member states. A WHO record, therefore, is a form of accountability to both the UN bureaucracy and the UN member states.

Third, PMI manages malaria across different nations outside the U.S. hence it has to delegate most of its antimalarial operations to third party entities. This delegation of PMI's antimalarial activities implies that PMI is only able to know the local reality of the malaria situations in each country via third party entity-created records. Each organization and nation has different culture and norms, hence the non-PMI staff members that create such records may not necessarily share the same culture and norms as PMI staff. In contrast, recordkeeping within PMI differs from organizations that deal with wicked problems within a *single* country (e.g., the Department of Energy). Recordkeeping in such organizations can be easily explained because they are embedded in the U.S. federal government recordkeeping framework that is overseen by

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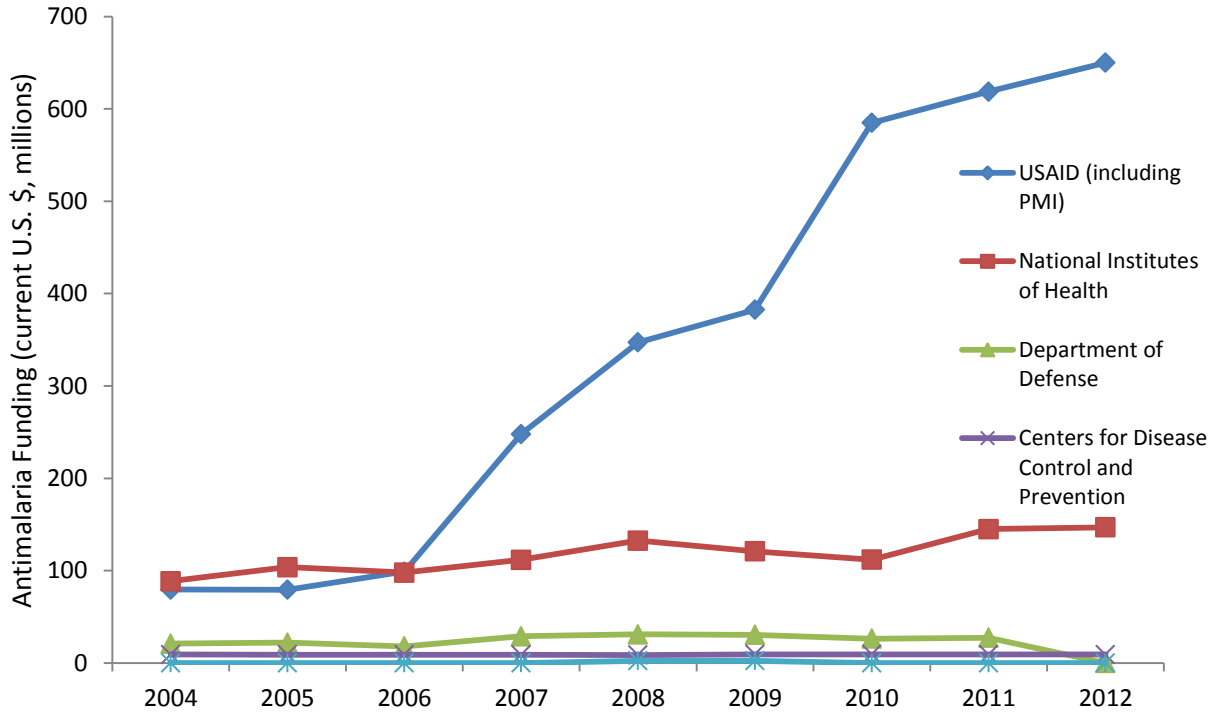
<sup>18</sup> This long "battle" against malaria is much longer than the history of Human immunodeficiency virus infection/acquired immunodeficiency syndrome (HIV/AIDS) that was first observed in the 1980s (Barre-Sinoussi et al. 1983; Gallo et al. 1983).

the National Archives and Records Administration (NARA) and the Office of Management and Budget (OMB).

Another potential case study is CDC. CDC is the U.S. government agency that possesses the best scientific and technical knowledge on malaria and antimalarial measures. CDC meets the second case selection criterion because it—similar to PMI—is funded solely by the U.S. Government. Nevertheless, CDC does not meet the other two of the three case selection criteria. CDC deals with multiple wicked problems hence it does not meet the first criterion. This creates an identification problem because a CDC record on antimalarial measures in the U.S. could also be used as part of other CDC operations (e.g., monitoring of avian influenza). Finally, CDC does not meet the third criterion because it deals with malaria within and outside the U.S. vis-à-vis PMI which deals only with malaria outside the U.S. The key difference between PMI and CDC is the organizational rationale; PMI aims to ameliorate part of the global public health problem of malaria while CDC's main organizational rationale is to manage some aspects of public health problems within the U.S.

Beside the three case selection criteria, the choice of PMI as a case study is of practical significance because it is the U.S. Government's lead agency in its global antimalarial efforts. From 2004 to 2012, the U.S. Government allocated much more funding to PMI via USAID than to CDC (Figure 3.1). The gap between the U.S. Government's funding to PMI-USAID and CDC widened from a difference of 80 percent in 2004 to 7000 percent in 2012. Furthermore, PMI is a key organization in combating global malaria; it spent the second largest amount of money in the global antimalarial efforts from 2005 to 2012 (WHO 2011b, 15, 17).

Figure 3.1. Recipients of the U.S. Government’s antimalarial funding (2004-2012)



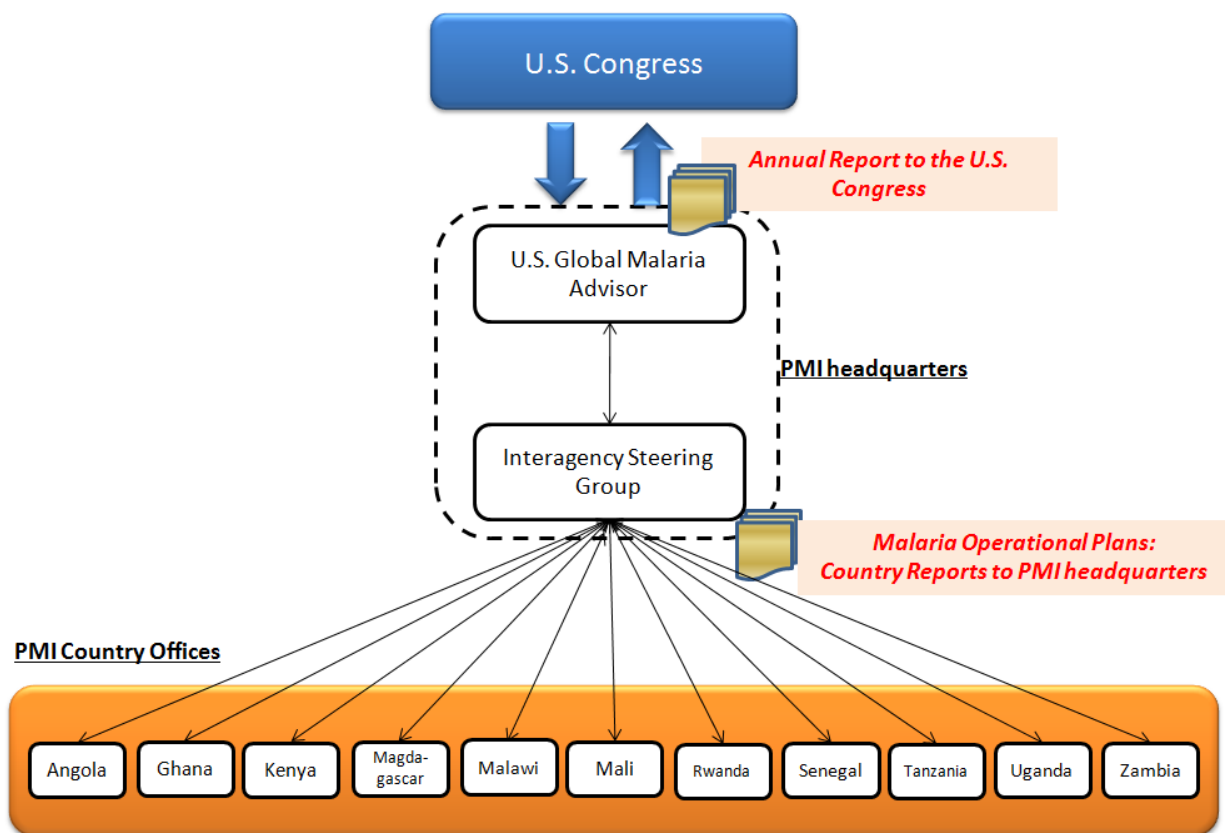
Note: Data are from Kendall (2012, 41).

### 3.2. Overview of PMI and its Recordkeeping Processes

PMI is an “interagency initiative led by USAID and implemented together with CDC” (Simon et al. 2011, iii). The U.S. Global Malaria Coordinator and the Interagency Steering Group are the two most important actors in PMI headquarters. The latter consists of representatives from USAID, CDC, Department of State, Department of Defense, National Security Council, and Office of Management and Budget (Figure 3.2). The two most important PMI records are PMI’s annual report to the U.S. Congress and PMI country offices’ annual Malaria Operational Plans (MOPs). PMI’s annual report to the U.S. Congress is created by PMI headquarters and it is the main record of PMI’s accountability to the U.S. Congress. This record highlights PMI’s progress

in antimalarial efforts in terms of target achievement and usage of funding. The second most important PMI record is each PMI country office’s annual report to PMI headquarters—MOPs. As of 2011, PMI has eleven PMI country offices in Africa and each PMI country office sends their respective MOPs to PMI headquarters.

Figure 3.2. PMI Records in relation to PMI’s accountability mechanisms



Note: PMI also operates in non-African countries.

The complexity of PMI’s antimalarial tasks is exemplified by its delegation of most of its antimalarial activities to third party entities across the eleven PMI focus countries (Figure 3.3). PMI country offices also form “technical working groups (TWGs), task forces, and work streams”

to coordinate various PMI-funded antimalarial activities (Simon et al. 2011, 2). PMI’s delegation of antimalarial activities to third party entities are captured in records in a variety of forms (e.g., survey data, contracts, and reports). Using PMI-Tanzania Office’s antimalarial activities in Tanzania as an example, about 95.6 percent of PMI-Tanzania Office’s projected budget for fiscal year 2012 (excluding PMI-Tanzania Office’s administrative overhead) was allocated to non-Tanzanian non-government actors (USAID 2012a). These non-Tanzanian actors (e.g., Walter Reed Army Institute of Research and Research Triangle Institute) are usually U.S.-based groups with the expertise to conduct PMI’s antimalarial activities.

Figure 3.3. Records in PMI country office’s interactions with third party entities



PMI’s mission and organizational culture affect the nature of its recordkeeping. PMI’s main mission is to reduce the malaria burden in PMI focus countries and increase these countries’



long-term antimalarial capabilities. Accordingly, PMI's mission is exemplified in its four operational principles (Simon et al. 2011, 11):

- The use of a comprehensive, integrated package of proven prevention and treatment interventions;
- The strengthening of health systems and integrated maternal and child health program;
- The commitment to strengthen National Malaria Control Programs (NMCPs) and to build capacity for country ownership of national malaria control efforts; and
- Close coordination with international and in-country partners.

These four principles are measured by quantitative indicators and exemplify PMI's orientation towards antimalarial operations. These principles in turn perpetuate an organizational reality that shapes PMI's recordkeeping processes.

PMI is a hierarchical organization with the U.S. Global Malaria Advisor at the top and with PMI country offices reporting to PMI headquarters. The main PMI records reflect this real organizational reality (Table 3.1). The first record is the PMI annual report to the U.S. Congress and it is the most important PMI record where PMI's leader, the U.S. Global Malaria Advisor, signs off a record that documents PMI's antimalarial activities and its budget spending. The second most important PMI record is the PMI country offices' annual report—MOP—to PMI headquarters. This record is similar in function and structure to the PMI annual report to the U.S. Congress.

Table 3.1. Main PMI records

PMI Records	Created By Whom	For Whom
PMI annual report	PMI headquarters	U.S. Congress
PMI country office annual report (MOP)	PMI country offices	PMI headquarters
Contracts	PMI	Non-PMI entities
Quarterly reports (including financial reporting and performance monitoring)	Non-PMI entities	PMI

The other two main PMI records are contracts between PMI and its partners and PMI partners’ quarterly reports to PMI. The contracts stipulate the obligations of PMI and its third party vendors in specific collaboration on antimalarial activities while the quarterly reports are a form of accountability check by PMI on its third party vendors. The main message from Table 3.1 is clear: these main PMI records provide an important lens into PMI’s inner workings.

### 3.3. The Method of Interpretive Inquiry and Data

This thesis adopts a qualitative method of interpretive inquiry to examine the underexplored topic of recordkeeping within an organization that is managing a wicked problem. A qualitative approach is the most suitable method for examining an underexplored topic because it emphasizes the “processes and meanings that are not rigorously examined, or measured...and stresses the socially constructed nature of reality...and seek answers to questions that stress how social experience is created and given meaning” (Denzin and Lincoln 1994, 4). Almost all archival science works—to the best of the author’s knowledge—focus on recordkeeping in organizations that manage tame problems.

The first advantage of using interpretive inquiry is that PMI records are of good data quality hence this method would provide a more accurate picture of PMI’s inner workings than

other methods. Records enable a researcher to examine the “interpretations people give to their own actions and actions of others” (Smith 1992, 102). PMI staff members create the records as required by his or her job scope and will be less guarded in filling in a record than in an interview situation where he or she would be more guarded in answering questions about his or her work. In the case of using the method of interviewing, a PMI staff may not give his or her true response. As documentary research scholars have argued, the “writing and reading” of records in different contexts give different meanings to the records hence PMI records are “dead data” that enable the author to understand PMI’s inner workings (Derrida 1978; Gray 2004, 263; Hakim 1983). Accordingly, this thesis will be able to identify the “true” PMI recordkeeping processes via the interpretation of PMI records (Hodder 1994; Neuman 2011, 393-394).

Another advantage of using interpretive inquiry is that it is suitable for this thesis’ examination of the norms and beliefs that affect PMI’s recordkeeping. These PMI norms and beliefs are in turn a product of the interdependent interactions among actors and between actors and the environment (Geertz 1973; Schwandt 1994). Interpretive inquiry is commonly used in works that examine communities that manage complex issues or in case studies that apply actor-network theory (Latour 2005; Law 1986, 2004; Law and Hassard 1999; Mol and Law 2002; Thompson 2002). These works—like this thesis—focus on the interactions between actors, their mental models, and incentive structures. Interpretive inquiry is therefore the most suitable method because its premise is that actors within an organization socially construct the “reality” and the reality is what researchers make sense of (Angen 2000; Rorty 1989; Roth 1987).

While the best research design would be a random sampling of the universe of PMI records that were created from the first day of its formation, the author is unable to access PMI archives. The author therefore relies on the next best data available: PMI records that are

published on PMI's official website (<http://www.fightingmalaria.gov/>). The main advantage of using these records is that PMI publishes them on its website with the aim of—besides accountability to the public—portraying a corporate image of its successful antimalarial efforts. This portrayal of a corporate image is exactly what this thesis focuses on: PMI's externalization of multiple local realities into an organizational reality via recordkeeping. Furthermore, PMI, an U.S. government agency, publishes its records that would have the basic characteristics that suit this thesis' analytical purposes, i.e., “authenticity, credibility, representativeness and meaning” (Scott 1990).

There are, however, two potential disadvantages of using publicly available PMI records. First, there may be informal mechanisms that these publicly available records do not reveal. Nevertheless, this thesis aims only to understand the broad dynamics of recordkeeping within PMI hence these publicly available records will suffice. Second, there is a danger of selection bias because this thesis does not conduct a random sampling of PMI records (Hakim 1983; Platt 1981a, 1981b). Specifically, such an approach entails the author to draw a random sample of respondents from the universe of all PMI-created records from 2005 to 2012. Nevertheless, random sampling is less applicable in PMI's case because this thesis is interested in the role of *important* records in affecting organizational dynamics. Accordingly, the author conducts purposive sampling to analyze the organizational processes that shape the creation and use of important PMI records.

This thesis mitigates these two potential disadvantages by triangulation, i.e., comparing the information from the key PMI records with a 2011 external audit report of PMI (Simon et al. 2011). The audit report, conducted by an external team, would provide a credible perspective of PMI's inner dynamics. The author also used relevant information from interviews with experts

(e.g., Professor Charles Taylor from the University of California, Los Angeles) and PMI staff for additional insights. Finally, this thesis also uses academic articles and reports about PMI for alternative sources of information (e.g., Sherman 2011).

### *Alternative Methods*

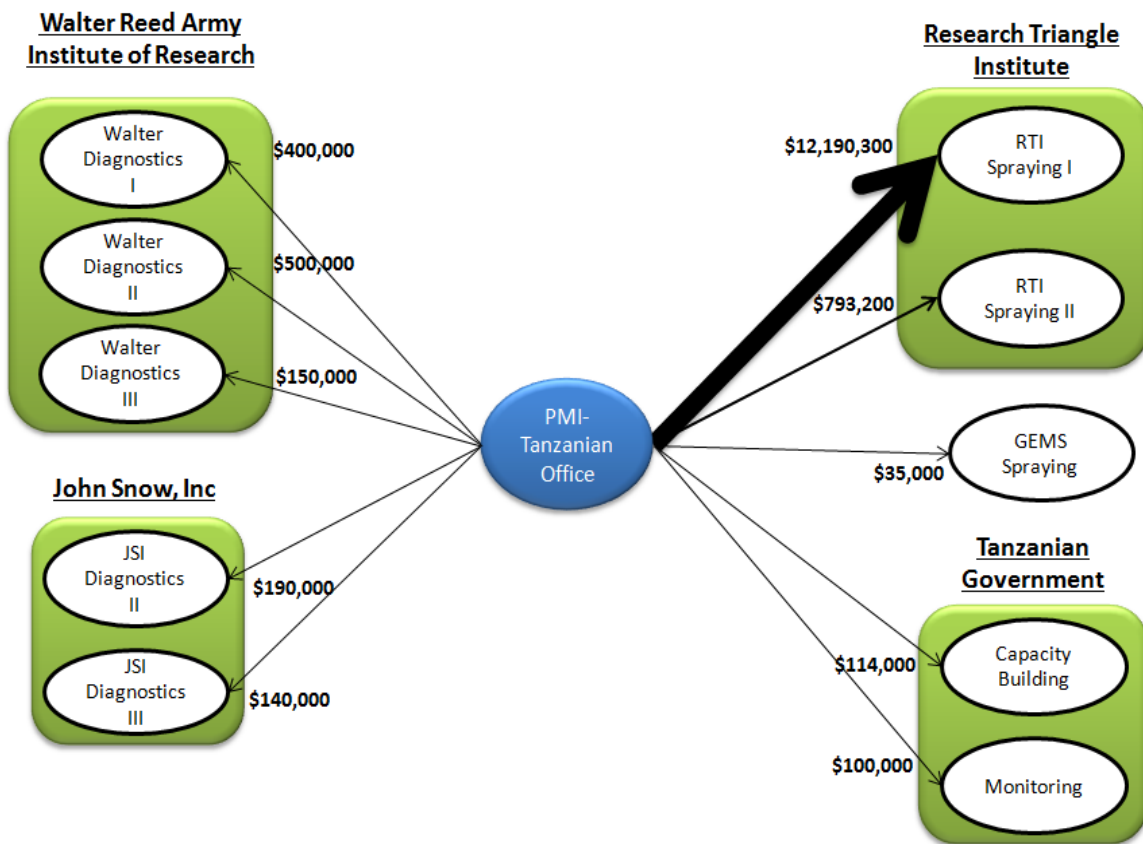
This thesis could not use two alternative methods for practical and research design issues. One is organizational ethnography, i.e., conducting ethnography of the everyday happenings within PMI. The author would ideally sit in a PMI office and adopt the approach of direct observation of PMI activities and staff behavior. This is not applicable to this thesis mainly because PMI activities are decentralized across different countries and among different hence, it will be resource intensive to conduct an organizational ethnography.

Another potential method is social network analysis. This is a frequently used method in the information science literature but it is less applicable for this thesis because of research design issues. The most important relationships that PMI engages are those with third party entities (e.g., the Tanzanian government and non-profit organizations). Nevertheless, best data available for social network analysis, the monetary value of PMI contracts with these third party entities does not capture the importance of this relationship. As Figure 3.4 shows, 83 percent of selected PMI projected funding for fiscal year 2012—US\$ 12.2 million—was earmarked for a project that is directed by a non-government organization, the Research Triangle Institute (RTI) for indoor residual spraying (IRS). In terms of social network analysis, this is a strong network but it does not reflect the true level of importance of its relationship for PMI-Tanzanian Office.

As a matter of fact, PMI-Tanzanian Office's most important partner is the Tanzanian government. It would not be able to carry out extensive antimalarial projects in a cost-effective

manner without the Tanzanian government’s bureaucratic facilitation and provision of human resources. Nevertheless, the importance of the Tanzanian government to PMI-Tanzanian Office’s antimalarial efforts is not reflected in the amount of funding that PMI-Tanzanian Office was projected to give the Tanzanian government in fiscal year 2012. PMI-Tanzanian Office was projected to provide the Tanzanian government with a relatively *small* sum of US\$0.21 million vis-à-vis the allocated amount of US\$12.2 million to a third party vendor—RTI.

Figure 3.4. PMI-Tanzania Office’s budget allocation for different projects



Notes:

[1] Data are from USAID (2012), 77-81. The width of the arrows represents the amount of funding that PMI allocates to different third party entities.

[2] *RTI*: Research Triangle Institute; *GEMS*: Global Environmental Management Support; *Walter*: Walter Reed Army Institute of Research; *JSI*: John Snow Inc.; *Tanzania*: Tanzanian Government;

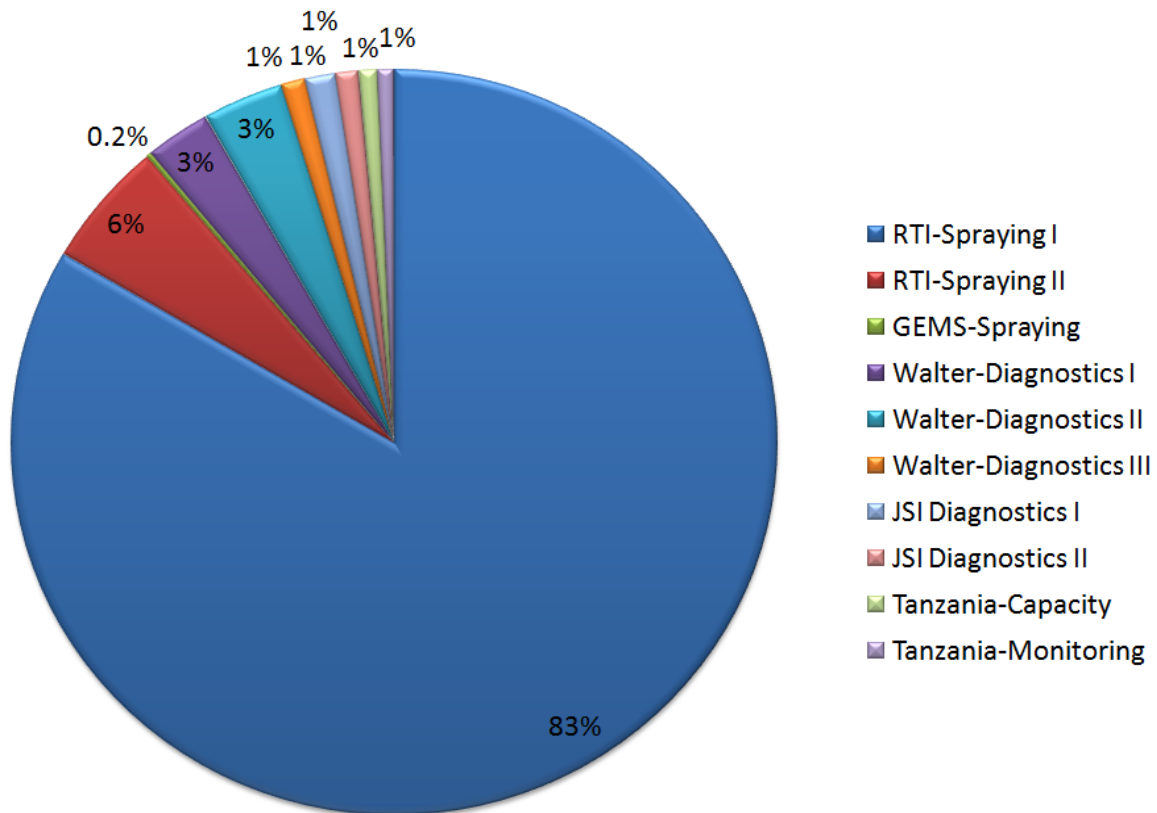
[3] *Spraying*: indoor residual spraying (IRS); *Diagnostics*: rapid diagnostic test (RDT).

In addition, it is not possible to standardize the amount of contract money because antimalarial activities differ in terms of unit costs. Indoor residual spraying (IRS), for instance, is qualitatively different from distribution of insecticide-treated bed-nets (ITNs). The former includes employing highly trained professionals to conduct the spraying while the latter requires lesser technical expertise because it only involves the distribution of ITNs. Using the same data as represented in Figure 3.4, Figure 3.5 shows that about 89.1 percent of selected PMI funding is used for three PMI-funded antimalarial projects for indoor residual spraying (83 percent and 6 percent for the respective indoor residual spraying projects). Malaria diagnostic projects that are scheduled to be conducted by the Walter Reed Army Institute of Research (WRAIR) form another seven percent of the selected PMI-Tanzania's projected budget for fiscal year 2012. It cannot infer that PMI-RTI relationship is stronger than the PMI-WRAIR relationship simply because PMI allocated more funds for RTI projects than for WRAIR projects.<sup>19</sup> Indoor residual spraying (IRS) projects have higher labor costs and capital investment than malaria diagnostic projects. Accordingly, social network analysis is not appropriate for this thesis because the vast difference in the amount of PMI-allocated funds are due to the scale of the antimalarial projects rather than the nature of the relationship between PMI and these third party vendors.

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<sup>19</sup> PMI project to spend US\$12.19 million (89.1 percent of the selected PMI funding) with RTI vis-à-vis the much smaller amount of US\$1.05 million on projects with WRAIR (Figures 3.4 and 3.5).

Figure 3.5. Comparison of selected funding to PMI-Tanzania Office’s partners



Notes:

[1] Data are from USAID (2012), 77-81.

[2] *RTI*: Research Triangle Institute; *GEMS*: Global Environmental Management Support; *Walter*: Walter Reed Army Institute of Research; *JSI*: John Snow Inc.; *Tanzania*: Tanzanian Government;

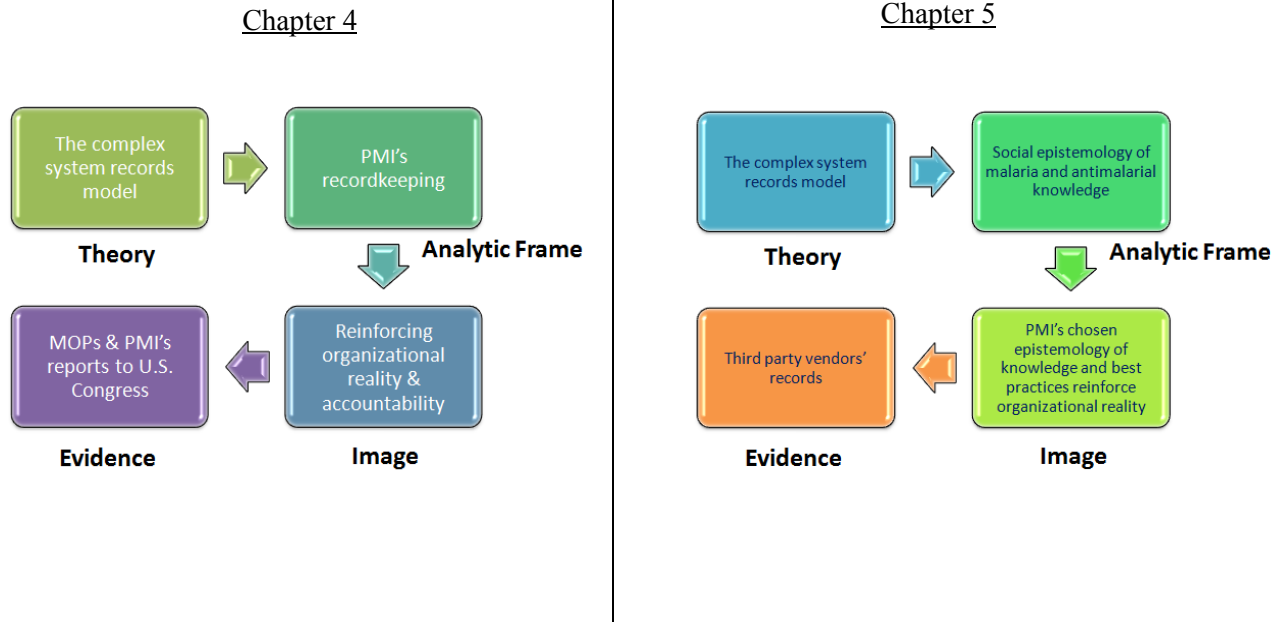
[3] *Spraying*: indoor residual spraying (IRS); *Diagnostics*: rapid diagnostic test (RDT).

### ***Validation Strategy***

This thesis’ validation strategy is shown in Figure 3.6. In chapter 4, the analytic frame is PMI’s recordkeeping, i.e., how PMI uses records that are created by third party entities to create its own records. Thus, the *theory* (the complex system records model) and the *analytic frame* (PMI’s recordkeeping) create a focal point for the author to search for evidence that validates the theory (see Ragin and Amoroso 2011). The author next chooses the evidence that supports the theory, i.e., the Malaria Operational Plans (MOPs) and PMI’s annual reports to the U.S. Congress.



Figure 3.6. The validation strategy of the complex system records model



Note: MOP: Malaria Operational Plan

The same validation strategy is adopted for Chapter 5. Starting from the complex system records model (*theory*), Chapter 5 uses the social epistemology of malaria research in scientific communities as the *analytic frame*. With the theory and analytic frame as the focal points, Chapter 5 uses the evidence from records that are created by PMI's third party vendors. The *image* is that of PMI choosing the best practices from WHO and CDC and thereby shapes the contract between PMI and its third party vendors (Figure 3.6). Consequently, when these third party vendors create reports—a form of records—to update PMI on the status of the projects, these reports have to conform to PMI requirements.

### 3.4. Conclusion

This chapter explained the rationale for choosing PMI, and provided an overview of PMI's recordkeeping processes. PMI is chosen as the case study because it fulfills the three case

selection criteria and the method of interpretive inquiry best serves to understand the rationale of PMI's recordkeeping processes. The complex system records model centers on the social construction of local reality by actors and how recordkeeping reinforces the socially constructed organizational reality. The next two chapters, Chapters 4 and 5, will provide the empirical evidence in support of the complex system records model.

## Chapter 4 Case Study I: PMI's Annual Reports

This chapter presents a case study on the most important aspect of PMI's recordkeeping: the creation and usage of the annual reports that PMI headquarters and PMI country offices create. This chapter validates the complex system records model and shows that it better explains PMI's recordkeeping process than extant models. The chapter begins with an in-depth discussion about the recordkeeping process involved in the creation of the Malaria Operational Plan (MOP)—an annual report of each country's antimalarial activities. Section 4.2 shifts the focus to PMI headquarters' creation of the annual report to the U.S. Congress. Section 4.3 then discusses the theoretical contributions of complex system records model and other competing models, and section 4.4 concludes.

### 4.1. The PMI-Tanzania Office and its Annual MOPs

Each PMI country office submits an annual MOP to PMI headquarters in Washington D.C. to report on its antimalarial efforts and to seek funding approval for the next fiscal year. This section focuses on PMI-Tanzania Office because Tanzania is a key malaria hotspot and it is one of the top recipients of PMI funding (USAID 2012a; WHO 2011a).<sup>20</sup> With the lives of millions of Tanzanian citizens at stake and a substantial amount of funding involved, PMI-Tanzania

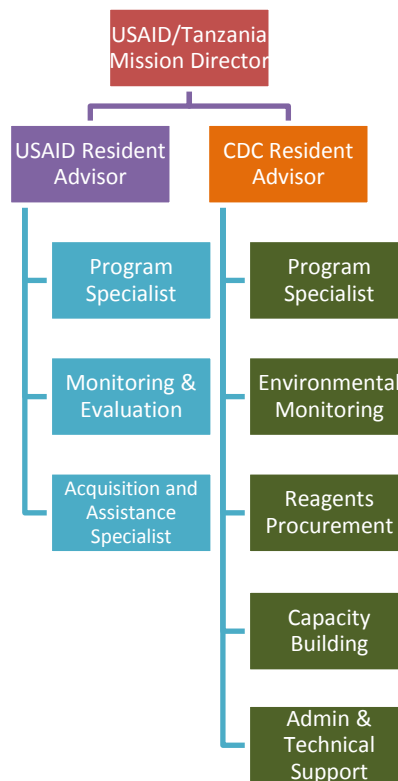
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<sup>20</sup> At least 90 percent of the Tanzanian population is at risk for malaria infection (RTI International 2012). PMI-Tanzania Office is the Tanzanian government's second largest sources of external financial support for the Tanzanian government's antimalarial program. The PMI-Tanzania office's funding accounted for about 33 percent of the Tanzanian government's expenditure for its antimalarial programs from 2003 to 2010 (WHO 2011a, 26).

office’s recordkeeping processes would provide a good case for the author to test the complex system records model.

The USAID and CDC staff members shape the content of its annual MOP (Figure 4.1). USAID formally oversees PMI but it relies heavily on CDC’s antimalarial expertise (Simon et al. 2011, 3). In 2011, there were four USAID staff and six CDC staff working under the USAID/Tanzania Mission Director. The USAID resident advisor supervises three other USAID staff: program specialist, monitoring and evaluation specialist, and acquisition and assistance specialist; and the CDC resident advisor supervises five CDC staff: program specialist, environmental monitoring, reagents procurement, capacity building, and administration and technical support.

Figure 4.1. PMI-Tanzania Office’s staff composition



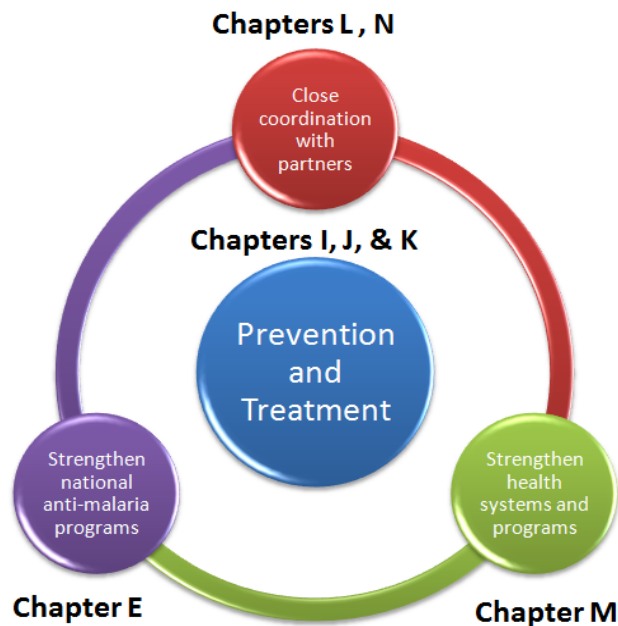
Source: USAID (2012a), 75-6.

### 4.1.1 Record Structure and Record Content

As Figure 4.2 shows, PMI-Tanzanian Office’s MOP is a quantitative report that emphasizes PMI’s antimalarial progress in relation to PMI’s four principles (ibid., 11):

- Chapters I, J, and K : the use of a comprehensive, integrated package of proven prevention and treatment interventions;
- Chapter M: the strengthening of health systems and integrated maternal and child health program;
- Chapter E: the commitment to strengthen National Malaria Control Programs (NMCPs)—the Tanzanian government in this case—and to build capacity for country ownership of national malaria control efforts; and
- Chapters L and N: the close coordination with international and in-country partners.

Figure 4.2. PMI’s four principles and MOP



Note: The distribution MOP chapters are in accordance with PMI’s four principles.

Chapter I of the MOP, for instance, highlights the results of PMI antimalarial activities—delegated to third party entities—and focuses on five themes: insecticide-treated bed-nets, indoor residual spraying, intermittent preventive treatment for pregnant women, behavior change and communication, and private sector partnerships (USAID 2012a). These five themes are directly related to PMI’s first principle of the “use of a comprehensive, integrated package of proven prevention and treatment interventions” (ibid., 11).

#### ***4.1.2 The Context of the Record***

The complex system records model adequately explains PMI-Tanzania Office’s recordkeeping processes. The staff members of the PMI-Tanzania Office create its annual MOP based on third party entity records. The Tanzanian government-created records provide most of the data for PMI-Tanzanian Office’s MOP. These records include Demographic and Health Surveys (DHS), Malaria Indicator Survey (MIS), and Tanzania National Voucher Scheme (TNVS) (USAID 2012a, 66). Another source of records for PMI-Tanzanian Office is the Tanzanian government’s Health Management Information System (HMIS): a digital repository of records sent from the field sites across Tanzania (ibid., 68).<sup>21</sup>

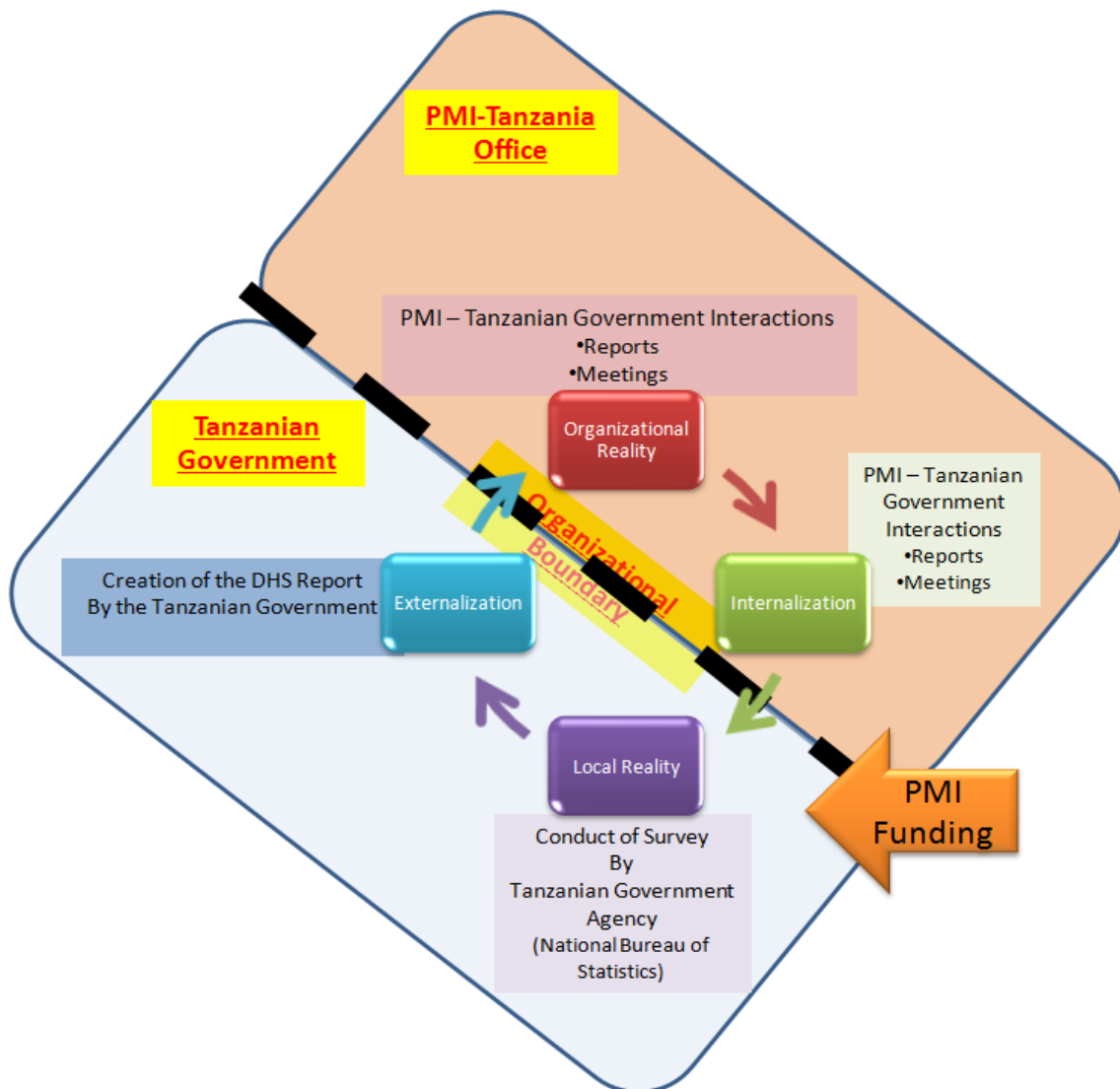
The Tanzanian government’s creation of the DHS report and PMI-Tanzanian Office’s usage of the DHS in creating its MOP exemplify the complex system records model’s explanatory power. Beginning from the bottom of Figure 4.3, there are multiple local realities of the malaria situation in Tanzanian villages, towns, and cities. A survey interviewer captures a microcosm of the local reality of malaria because his or her interviewees are chosen via a random sampling procedure. These snapshots of local realities are aggregated and externalized at

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<sup>21</sup> PMI included a US\$100 000 budget allocation—0.2 percent of fiscal year 2012 budget—to the Tanzanian government for improving its public health information systems (USAID 2012a, 68).

the Tanzanian government’s National Bureau of Statistics in the form of a record—the DHS report. The process for the creation of the record—the DHS report—filters off the complex nature of the multiple “true” local realities of the malaria situation on the ground. Specifically, the complex malaria situation in Tanzania is filtered into a highly simplified summary in four categories: mosquito nets, use of antimalarial drugs during pregnancy, treatment of children with fever, and anemia prevalence (National Bureau of Statistics 2011, 193-208).

Figure 4.3. The complex system records model and the creation of the MOP



The first two steps of the complex system records model—local reality and externalization—are carried out by the Tanzanian government with funding from PMI and other international organizations (Figure 4.3). The objectivation of the malaria situation in Tanzania in the form of a record—the DHS report—reinforces the mental models, knowledge, institutions, and rules within PMI-Tanzania Office. PMI-Tanzania Office, therefore internalizes this organizational reality via social mechanisms (e.g., meetings and informal discussions) and the cycle repeats in the next round of DHS.

PMI-Tanzania Office maintains its dominance in these relationships via its control of funding. As anecdotal evidence from the 2011 PMI external evaluation report states, “ultimately, PMI will fund or not fund what it wants to, using the implementing mechanisms available” (Simon et al. 2011, 13). Accordingly, PMI-Tanzania Office has the power to shape the type of survey data that the Tanzanian government survey interviewers would ask Tanzanian respondents; these questions in turn filter off the information that PMI is less interested in. This phenomenon is congruent with archival science works that have shown that the power dimension is a critical factor that affects the recordkeeping process (Trace 2002; Yakel 1996).

## **4.2 PMI Headquarters’ Report to the U.S. Congress**

This section shifts the focus from the recordkeeping processes in PMI country offices across different countries to PMI headquarters. The inputs for this annual report come largely from the PMI country office-created MOPs. A larger historical context affects PMI’s organizational development. PMI began its role as U.S. Government’s leading global antimalarial agency in reaction to perceived ineffectiveness of USAID’s global antimalarial efforts (Atwood et al. 2008;



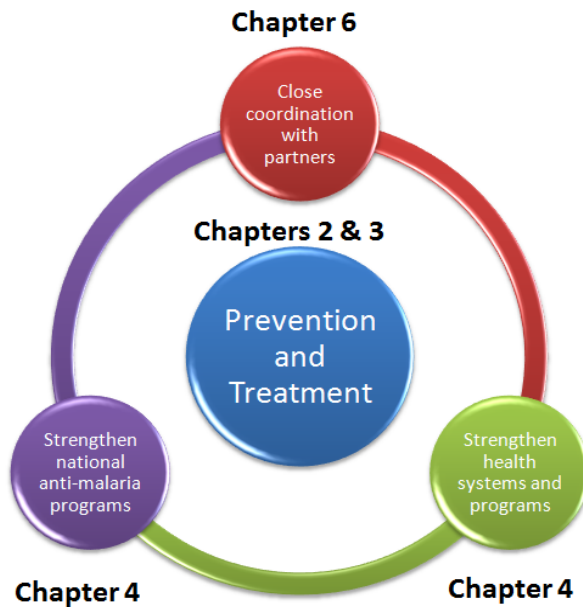
Bate 2003; Bristol 2011).<sup>22</sup> Accordingly, accountability via transparency is evident in PMI's recordkeeping processes and the need to show continuous progress in PMI's antimalarial programs is exemplified in the large amount of quantitative information in PMI's annual reports to the U.S. Congress.

The content of PMI's annual report to the U.S. Congress is more comprehensive than PMI country offices' annual reports to PMI headquarters (i.e., MOPs). This record includes chapters that adhere to the four principles but it includes additional parts, i.e., Malaria Research and Innovation, PMI Funding FY2006-2011, PMI Contribution Summary, and PMI Country-Level Targets (Figure 4.4). Accordingly, PMI's annual report to the U.S. Congress serves the dual purpose of accountability and the portrayal of a corporate image of PMI being transparent and effective in its antimalarial efforts.

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<sup>22</sup> USAID, for instance, only spent less than ten percent of its 2004 budget—one year before the start of PMI—on the procurement of antimalarial equipment such as insecticide-treated bed-nets (Bate 2007).

Figure 4.4. PMI’s four principles and PMI’s annual report to the U.S. Congress (2012)



Additional Parts:

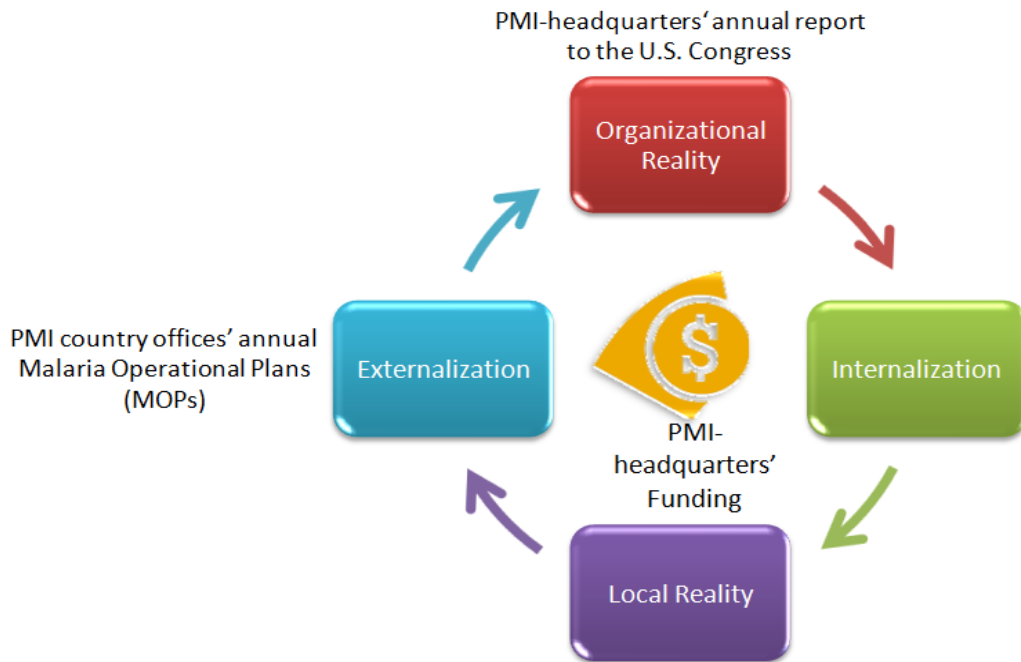
- Malaria Research and Innovation
- PMI Funding FY2006-FY2011
- PMI Contribution Summary
- PMI Country-Level Targets

Notes: The distribution of the chapters in PMI’s annual report to the U.S. Congress (i.e., chapters 2, 3, 4, and 6) are in accordance with PMI’s four principles (i.e., the four colored circles). The data are from USAID (2012a).

PMI headquarters rely mainly on the PMI country offices’ annual MOPs—PMI’s important records—for information. This differs greatly from the PMI country offices’ creation of the MOPs—as described in section 4.1—where these country offices rely heavily on third party entity-created records. As Figure 4.5 shows, PMI headquarters have a socially constructed perspective of the multiple local realities of the malaria problems across different countries. This perspective is socially constructed because the PMI country offices’ staff members externalize the respective local realities in each country into the respective MOP. PMI headquarters staff members in turn socially construct an organizational reality that adheres strongly to the four principles by aggregating the statistics from the MOPs. Consequently, PMI headquarters’ annual report to the U.S. Congress and PMI country offices’ MOPs perpetuate the four PMI principles

via the process of internalization. As shown in Figures 4.3 and 4.5, the PMI headquarters influence PMI country offices' framing of their MOPs with its control of financial resources.

Figure 4.5. PMI's annual report to the U.S. Congress and MOPs



### 4.3 Theoretical Discussion

Sections 4.1 and 4.2 have shown that the complex system records model provides a convincing explanation of PMI's recordkeeping. This thesis argues that the complex system records model better explains recordkeeping in an organization that deals with wicked problems—PMI in this case—better than the records continuum model.

The records continuum model is a flexible model that could also explain recordkeeping within PMI because the records continuum model by its construct is meant to be flexible.<sup>23</sup> As Frank Upward—one of the leading continuum scholars—has stated, “features [of the records continuum model] are labeled independently of any time period or professional loading...[and] within any implementation environment...the terms will be given specific interpretations and meanings” (Upward 1996, 277-8). Accordingly, one could use the records continuum model to explain PMI’s recordkeeping in the following way: each PMI country office’s MOP is created (dimension 1), captured (dimension 2), organize (dimension 3), and pluralize (dimension 4). The MOPs could also be framed along the records continuum model’s evidential axis where it provides a form of organizational memory for PMI and be part of the collective memory for the global antimalarial regime.

Nevertheless, the complex system records model better explains PMI’s recordkeeping than the records continuum model in two ways. First, the complex system records model is a dynamic model that captures the *process* of recordkeeping within PMI. Section 4.1 has shown how PMI uses third party entity-created records (e.g., Tanzanian governments and third party vendors) and how these processes relate to PMI’s organizational dynamics. The complex system records model states that the local reality of malaria situation in Tanzania is captured by survey questions and the corresponding survey responses are in turn aggregated into a survey report. Different actors have different perceptions of the local reality and the survey report—a record—to a large extent reports only some aspects of the multiple perceived realities by making “order from chaos” (Latour and Woolgar 1979). The records continuum model, however, does not relate these micro-level processes to macro-level organizational dynamics. To be fair, the records

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<sup>23</sup> The records continuum has four axes (recordkeeping, evidence, transactional, and identity) and four dimensions (create, capture, organize, and pluralize). See section 2.4 for a detailed comparison between the complex system records model and the records continuum model.

continuum model mentions the importance of records as the creation of corporate memory at the macro level but it misses the more important micro-level dynamics.

Second, the complex system records model frames the importance of context in recordkeeping differently from the records continuum model. As extant works in archival science have argued, the context of an organization's recordkeeping is important (Trace 2002; Yakel 1996). A uniqueness of PMI's recordkeeping is that the records come from different jurisdictional authorities: within PMI and outside PMI (i.e., third party entities such as national governments and vendors). The complex system records model highlights the socialization and professionalization processes in recordkeeping that are congruent with PMI's goal of combating malaria across different nations. This insight is consistent with extant works on the sociological aspects of recordkeeping within organizations. As archival science scholars have long argued, "organizational records...are fundamentally self-conscious and self-interested" (van Manent and Brian Pentland 1994, 53). The records continuum model, by contrast, does not highlight this aspect of recordkeeping although it mentions the importance of recordkeeping in creating "corporate memory" in the evidence axis (Upward 1996, 279).

#### **4.4. Conclusion**

Records are not created equal. This chapter has validated the complex system records model and has shown how the two most important PMI records—PMI's annual report to the U.S. Congress and PMI country offices' annual MOPs—perpetuate PMI's organizational reality. The complexities of malaria—a wicked problem—have been streamlined into simple malaria outcome indicators that PMI and its third party entities actively monitor. These snapshots of the "true" local reality are captured by third party entities and PMI internalized them as part of its

organizational reality. Given the complexity of malaria as a wicked problem, how do PMI and its partners—third party entities—know which epistemology of knowledge and best practices that they should adopt? The next chapter will examine this question in details.

## **Chapter 5 Case Study II: Social Epistemology of Scientific Knowledge and PMI's Recordkeeping**

Recordkeeping and records are vital components of the information infrastructure that serves networks of scientific communities (Star and Ruhleder 1996). This chapter focuses on the nexus between archival science and biomedical informatics. As explained in Chapters 3 and 4, PMI's business model is the delegation of its antimalarial activities to third party entities. Chapter 4 has shown how the complex system records model explains PMI's recordkeeping processes: the externalization of local realities and creation of an organizational reality. Chapter 5 uses a different set of PMI records—records of PMI's interactions with third party entities—to explain how PMI's choice of the epistemology of malaria and best practices in antimalarial programs affect its recordkeeping. Section 5.1 begins by setting the context for describing the antimalarial epistemic communities that PMI is embedded in and section 5.2 explains PMI's choice of the social epistemology of malaria transmission, antimalarial best practices, and the subsequent effects on its recordkeeping practices. Section 5.3 uses empirical evidence to show the complex system records model's explanatory power. Section 5.4 discusses this thesis' theoretical contributions to archival science and biomedical informatics and section 5.5 concludes.

## 5.1. PMI and the Antimalarial Epistemic Communities

The complex system records model explains the nature of recordkeeping within an organization that manages a wicked problem. PMI uses an evidence-based policy approach where it rigorously quantifies its antimalarial program goals and has an institutionalized policy feedback mechanism. PMI is part of an epistemic community that centers on WHO's network of antimalarial groups and CDC's network of research institutes and a global policy network.<sup>24</sup> An epistemic community is a “network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area” (Haas 1992, 3). Consequently, this epistemic community has “a shared notion of validity that is intersubjective and is an internally defined criteria for weighing and validating knowledge in the domain of their expertise” (ibid.).

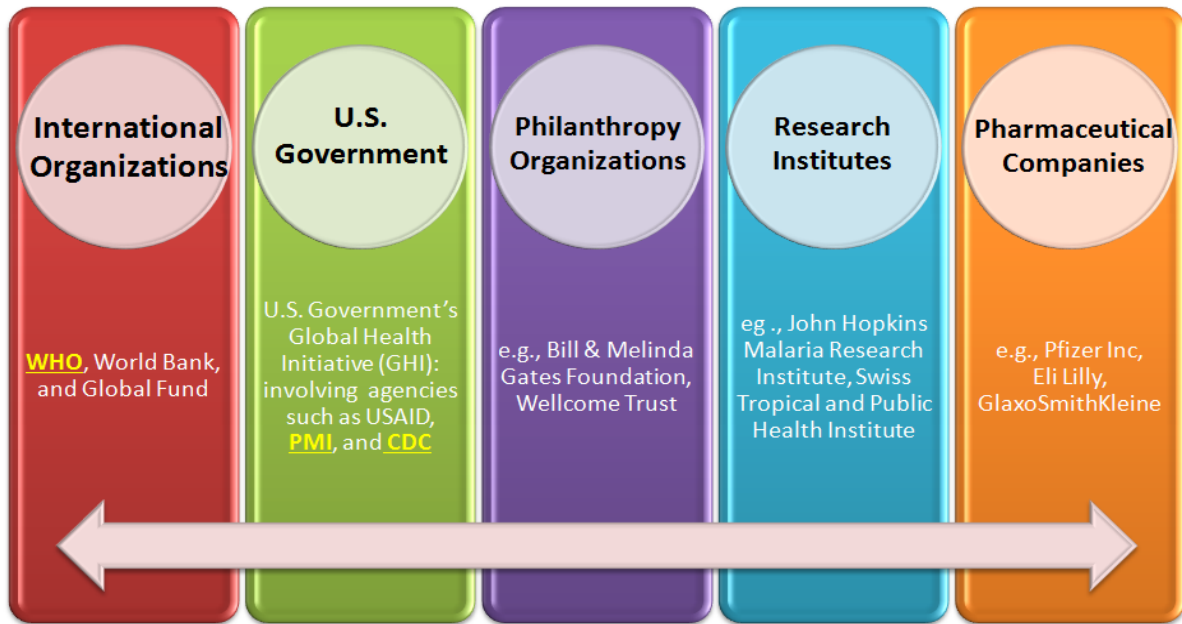
There are five main epistemic communities in the global antimalarial regime: international organizations, the U.S. Government, philanthropy organizations, research institutes, and pharmaceutical companies (Figure 5.1). PMI adopts the “best practices” approach from WHO and CDC (Bendavid and Miller 2010; Loewenberg 2007, 1894; PMI 2008; USAID 2010). PMI also benefits from the U.S. antimalarial research networks that include public sector agencies such as the National Institute of Allergy and Infectious Diseases (NIAID), educational institutes (e.g., John Hopkins Malaria Research Institute), and pharmaceutical companies (e.g., GlaxoSmithKline).

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<sup>24</sup> CDC's networks of research institutes depend highly on funding from CDC's mother institution, the Department of Health and Human Services, and CDC's sister agency, the National Institutes of Health (NIH).



Figure 5.1. Epistemic communities in the global malaria regime

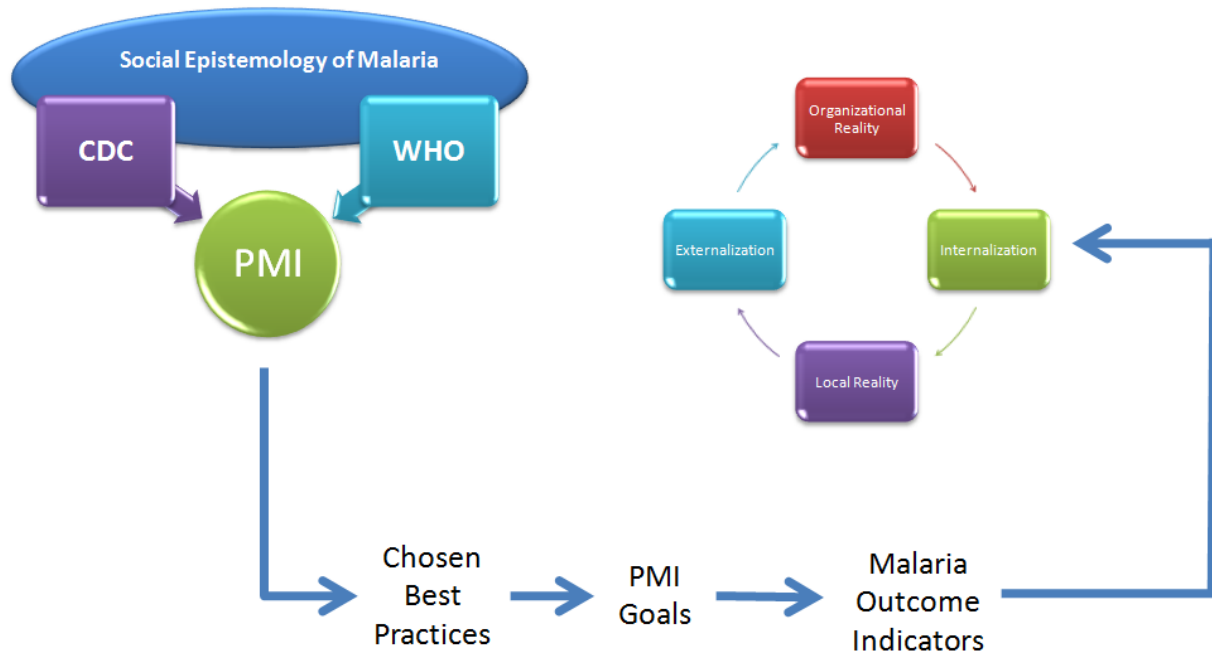


PMI's usage of the WHO-CDC best practices serve its organizational purposes in two ways: it legitimizes the utility of its antimalarial policies and reduces the resources spent on creating an original PMI approach. The legitimization process increases PMI's organizational effectiveness because PMI leverages upon WHO's prestige as the most important antimalarial organization in the world and CDC's reputation as the leading U.S. government agency with the best antimalarial technical experts (WHO 2011b, ix). PMI could therefore spend its valuable resources on antimalarial programs rather than on antimalarial research.

The complex system records model frames the linkage between biomedical informatics and archival science in PMI's recordkeeping. The top left part of Figure 5.2 shows that PMI is embedded in the WHO-CDC epistemic community and it chooses the best practices from this epistemic community. These chosen best practices are in turn externalized into achievable antimalarial goals, and manifest as terms of malaria outcome indicators and third party entity-

created records.<sup>25</sup> The malaria outcome indicators are internalized into PMI's organizational reality and become the cognitive filters that affect how actors *perceive* the local reality of malaria.

Figure 5.2. The complex system records model and the WHO-CDC approach to malaria



## 5.2. The Social Epistemology of Malaria Transmission and Antimalarial Best Practices

PMI's choice of the social epistemology of malaria transmission and antimalarial best practices affect its recordkeeping. Knowledge is closely connected with social ontology and social

<sup>25</sup>Examples of malaria outcome indicators include the percentage households with at least one insecticide-treated bed-net (ITN) and the percentage of targeted houses adequately sprayed with a residual insecticide.

epistemology of malaria transmission.<sup>26</sup> The dominant social epistemology of malaria transmission that is widely acceptable in the antimalarial epistemic communities centers on parasite life cycle and the local environmental conditions (Chitnis et al. 2010; García-Basteiro et al. 2012; Hall and Fauci 2009) (Figure 5.3). PMI’s choice of this social epistemology of malaria transmission becomes its mental model of malaria transmission. An exemplification of this PMI mental model is the record—Malaria Operational Plan (MOP)—stating that the dominant strain of malaria vector in Tanzania is *Anopheles gambiae complex* and these vectors thrive in seasonal climate conditions (USAID 2012a, 11).

Figure 5.3. Social epistemology of malaria transmission



In the field of epidemiology, malaria researchers would quantify the social epistemology in Figure 5.3 into a quantitative malaria transmission model. One example is the Ross-Macdonald model and WHO uses it as part of a broad mathematical modeling approach to track malaria situation in focus countries (Chitnis et al. 2010, 20). The Ross-Macdonald model decomposes the complex phenomenon of malaria into a mathematical formula (Figure 5.4).<sup>27</sup>

<sup>26</sup> As defined in section 2.3.2, social ontology is about what actors perceive in the world that is for them to know is a result of social construction, such as “social entities” (Searle 2006). Social epistemology is “a state of affairs will only be taken to be evidence that something else is the case in light of some background belief or assumption asserting a connection between the two” (Longino 1990, 44; 2002).

<sup>27</sup> On the left-hand side of the formula,  $R$  is the basic mosquito reproduction rate; on the right hand side, seven variables are stated to affect  $R$ . These factors are  $m$ , female mosquitoes per person,  $a$ , frequency of mosquito bites,  $b$ ,

Because PMI adopts the social epistemology of malaria transmission from the WHO-CDC epistemic community, the Ross-Macdonald model in turn becomes PMI's mental model of malaria transmission (see Figures 5.1 and 5.2).

Figure 5.4. The Ross-Macdonald model

$$R_0 = \frac{ma^2b/hp^n}{-r \log_e P}$$

$R$  = basic mosquito reproduction rate  
 $m$  = female mosquitoes per person,  
 $a$  = frequency of mosquito bites,  
 $b$  = Sporozoite bites resulting in human infection,  
 $h$  = proportion of humans actually infectious,  
 $p$  = survival rate in mosquitoes,  
 $n$  = length aporogenic cycle in days, and  
 $r$  = recovery rate in humans-proportion recovering

Note: Adapted from Chilengi and Gitaka (2010)

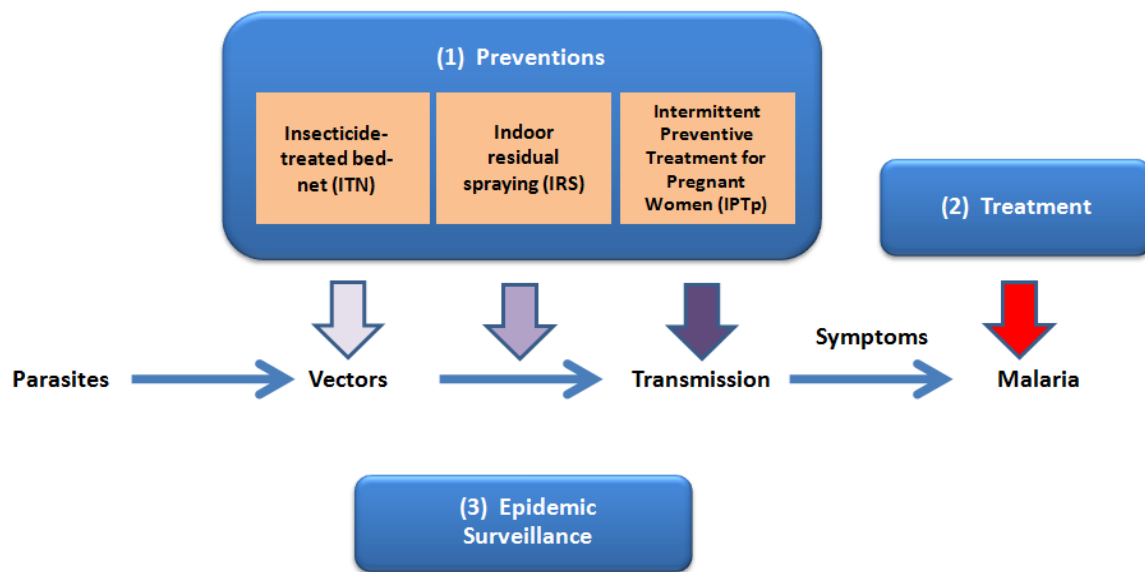
Figure 5.5 shows the effect of PMI's social epistemology of malaria on its antimalarial programs. Specifically, the vectors component—mosquitoes—is one part of this social epistemology of malaria transmission hence PMI adopts the antimalarial measure of insecticide-treated bed-nets (ITN). The next component in this social epistemology is the transmission process. PMI adopts the antimalarial measure of indoor residual spraying (IRS) to kill the vectors and intermittent preventive treatment for pregnant women (IPTp). These three types of prevention—ITN, IRS, and IPTp—are the WHO-CDC best practices. There are other ways to prevent malaria that PMI *chooses* not to adopt, e.g., the genetic control of malaria vectors.<sup>28</sup>

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Sporozoite bites resulting in human infection,  $h$ , proportion of humans actually infectious,  $p$ , survival rate in mosquitoes,  $n$ , length aporogenic cycle in days, and  $r$ , recovery rate in humans-proportion recovering (Chilengi and Gitaka 2010).

<sup>28</sup> This type of antimalarial measure entails the introduction of genetically modified vectors (i.e., mosquitoes) into a locality and the logic is that such genetically modified vectors would thrive in the locality; thereby reducing the relative number of vectors that transmit malaria (Marshall and Taylor 2009). The Bill & Melinda Gates Foundation, for instance, invests in antimalarial research that differs in orientation from WHO.

Figure 5.5. Social epistemology of malaria transmission and PMI’s antimalarial programs



PMI intervenes in the wicked problem of malaria along multiple points in the malaria transmission process based on a chosen social epistemology of malaria transmission (Figure 5.5). Each intervention point has different levels of uncertainty. For example, the decision to administer artemisinin-based drugs hinges on the proficiency of the health worker who must first diagnose accurately that a patient is suffering from malaria, and then administer the appropriate amount of artemisinin-based drugs. The symptoms of malaria, however resemble other health conditions hence the best diagnostic test is the use of microscope (Singh et al. 2010). PMI does not adopt microscopy for most of its antimalarial programs because of its high costs. It instead adopts cheaper and simpler tests (e.g., Rapid Diagnostic Tests) that WHO adopts for its antimalarial programs.

In summary, the complex system records model explains the effects of the complexities of malaria—a wicked problem—on PMI’s recordkeeping. PMI manages malaria by embracing a

particular social epistemology of malaria transmission, adopting best practices from established agencies, and creating quantifiable and measurable performance indicators. A combination of PMI delegation of antimalarial activities to third party entities and the complexities of malaria as a disease imply that PMI records have to capture these complexities by filtering information. PMI, as mentioned in Chapters 3 and 4, delegates the bulk of its antimalarial programs to third party entities, hence PMI knows the local reality of the malaria situation and the effectiveness of antimalarial programs via third party entity-generated records. The next section will use two case studies to illustrate this process.

### **5.3. Two Case Studies: PMI and Third Party Entities**

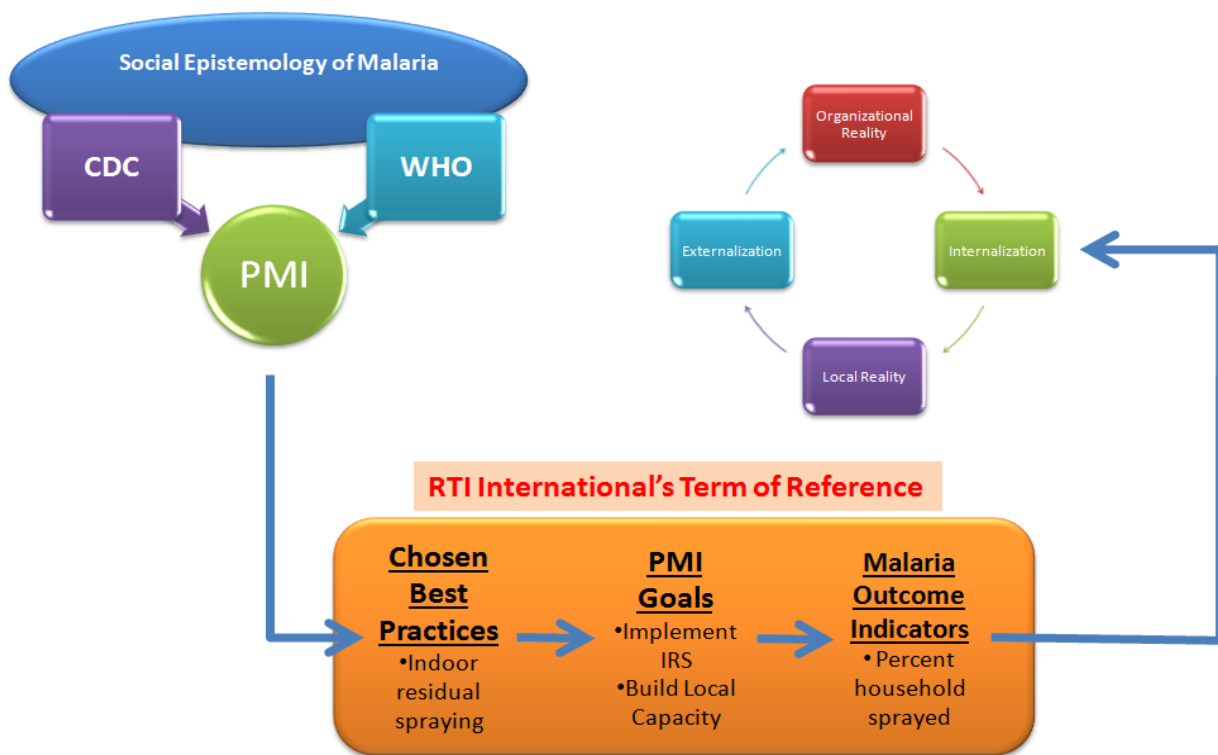
PMI is handling a wicked problem—malaria—hence it has to collaborate with third party entities and use their records for PMI’s recordkeeping. This section examines two case studies of PMI’s interactions with two third party entities: the Research Triangle Institute (RTI) International and the Medical Care Development International (MCDI).

#### ***5.3.1 PMI and RTI International***

RTI International is a non-profit organization that has an established reputation in implementing antimalarial programs. It is one of PMI’s most important collaboration partners and secures a steady flow of PMI funding. As section 3.3 has earlier discussed, RTI International was projected to receive 83.4 percent of selected PMI-Tanzania Office’s projected funding for fiscal year 2012. One important PMI-chosen best practice is indoor residual spraying (IRS). The record of interest is RTI International’s *Quarterly Report: Indoor Residual Spraying (IRS) for Malaria Control Indefinite Quantity Contract (IQC)* (RTI International 2008).

Figure 5.6 summarizes how the complex system records model explains the PMI-RTI International interactions. PMI legitimizes its antimalarial programs by using the dominant WHO-CDC social epistemology of malaria. This codification of PMI’s social ontology and social epistemology of malaria is evident in RTI International-created records (RTI International 2006). Linking back to Chapter 4, the RTI International-created records capture snapshots of local reality externalized these snapshots into records (e.g., quarterly reports to PMI). PMI uses these third party entity-created records as the evidence for PMI records (e.g., each PMI country office’s annual Malaria Operational Plan).

Figure 5.6. Prevention and IRS: PMI and RTI International



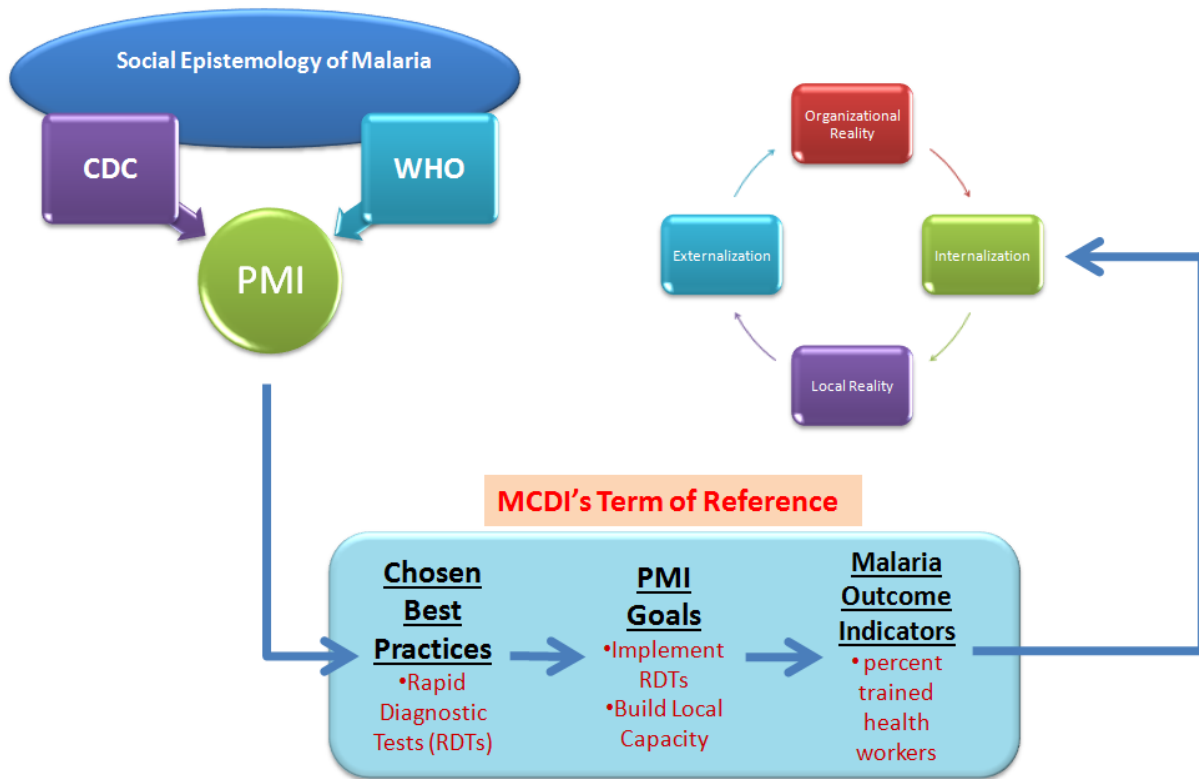
### ***5.3.2 PMI and MCDI***

PMI's antimalarial programs generate data at the local level and the data is recorded by non-PMI entities (e.g., Tanzanian government health officials and non-profit entities such as RTI International). As shown earlier in Figure 5.3, epidemic surveillance is one of the three main PMI antimalarial programs—the other two being malaria prevention and malaria treatment. The results of such epidemic surveillance—usually conducted by third party entities—serve the bureaucratic purpose of monitoring aggregate level of malaria situations across regions and countries.

Figure 5.7 summarizes the complex system records model's explanation of PMI's interaction with MCDI in epidemic monitoring. The current social epistemology on epidemic monitoring is the importance of having accurate and timely reports of malaria occurrence (Sullivan 2010). Scientists and practitioners in the antimalarial epistemic communities advocate the use of rapid diagnostic tests (RDTs). PMI uses WHO-CDC best practice—RDTs—and collaborates with MCDI to strengthen PMI's epidemic monitoring capabilities. This is internalized into PMI's organizational rationale and becomes PMI's organizational reality.



Figure 5.7. Epidemic monitoring and RDT: PMI and MCDI



#### 5.4. Theoretical Discussion

This thesis' complex system records model highlights the socio-political aspects of biomedical informatics. Biomedical informatics is an “interdisciplinary” field that focuses on the “effective use of biomedical data, information, and knowledge for scientific inquiry, problem solving, and decision making, driven by efforts to improve human health” (Kulikowski et al. forthcoming).

In terms of scientific records that are created for the purpose of scientific inquiry, this chapter has shown how an organization's choice of the ontology and epistemology of knowledge affects its recordkeeping. Most of the extant biomedical informatics works focus on the results of

clinical trials and embrace the data-hypothesis-theory-knowledge frame. As early as the 1980s, the Joint Committee on Archives of Science and Technology (JCAST) highlighted the importance of scientific records for scientific inquiry and bureaucratic purposes (Elliot, 1983). This framing is too narrow because each scientific process has an “epistemic purpose” (Grim forthcoming). Scientific inquiry is a highly messy process where scientists have to make “order from chaos” (Latour and Woolgar 1979). Ultimately, the complex system records model states that the social epistemology of knowledge forms the reference point for biomedical scientists to create scientific records.

Another contribution of this thesis is that the complex system records model differentiates between records and information. The complex system records model introduces the concept of inequality of records where some important records function as attractors that affect organizational development (see Table 2.2 in section 2.4). Most biomedical informatics research on information representation tends to commoditize information into modular forms to facilitate information retrieval. Nevertheless, there are other important records that extant biomedical informatics works do not emphasize such as a hospital’s annual report to its stakeholders. Accordingly, future biomedical informatics works should differentiate these two types of records—patient record and hospital record—because the patient record facilitates the physician’s task by presenting the patient medical history while the hospital records are organizational records that promote the growth of the hospital as an organization.

## **5.5. Conclusion**

This chapter finds strong support for the complex system records model. Using a different set of PMI records from Chapter 4, i.e., records of PMI's interaction with these third party entities, this chapter has shown how PMI's choice of an epistemology of knowledge and best practices affects its recordkeeping processes. This novel examination of the interactions between an organization's recordkeeping and its embracement of a particular social epistemology and best practices further highlights the validity of the complex system records model as a robust model in explaining recordkeeping in organizations that manage wicked problems.

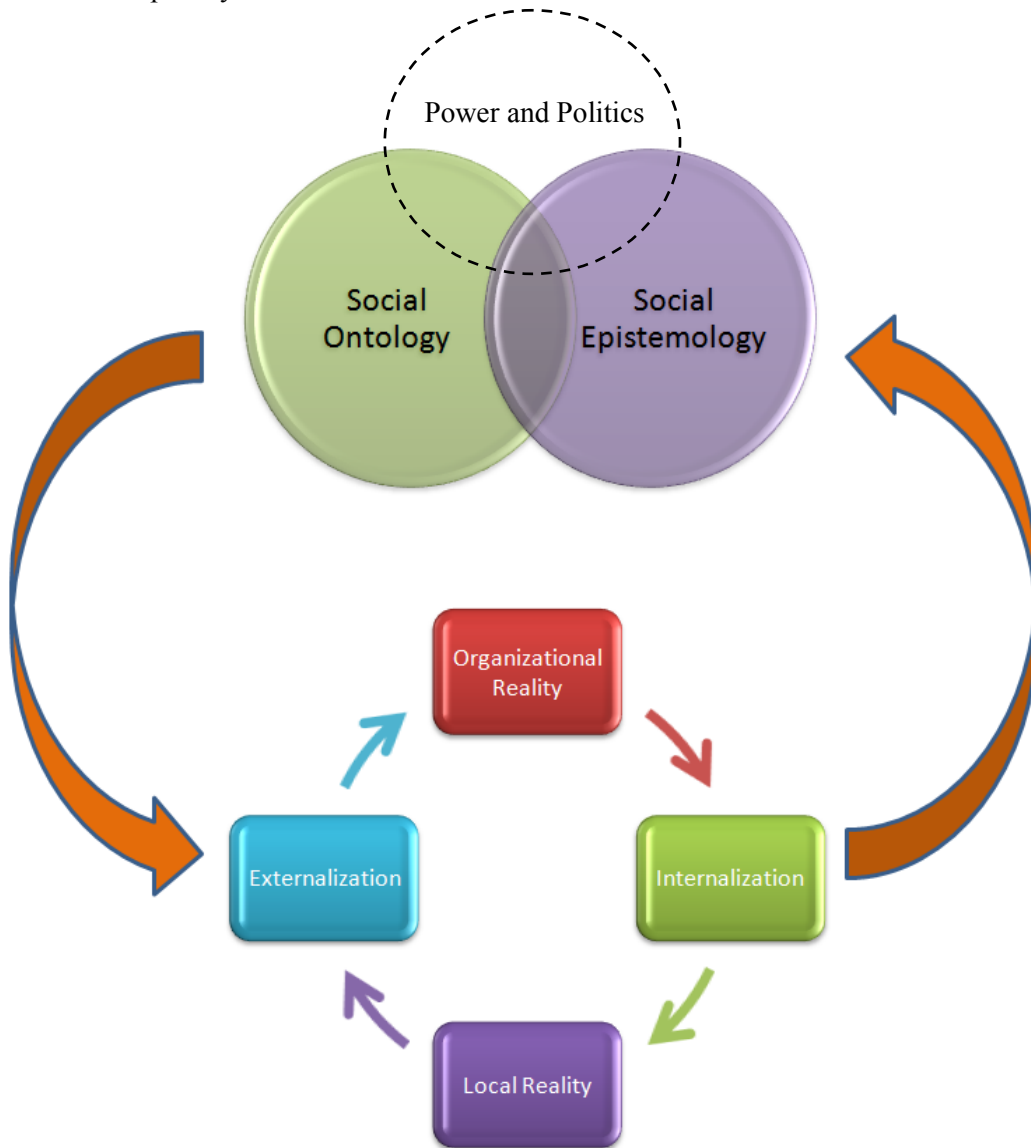
## Chapter 6 Conclusion

This thesis presents a model—the complex system records model—that explains an underexplored aspect of recordkeeping, recordkeeping in an organization that manages wicked problems. By using PMI as the case, this thesis finds strong empirical support for the complex system records model. The model states that organizations use recordkeeping to perpetuate an organizational reality. In addition, an organization embraces a particular social epistemology of knowledge and “best practices” that in turn affect the nature of recordkeeping. Chapter 4 has shown how PMI perpetuates an organizational reality via the two most important records: PMI’s annual report to U.S. the Congress and PMI country offices’ annual reports to PMI headquarters, i.e., the Malaria Operational Plans (MOPs). These two most important PMI records function as attractors that perpetuate PMI’s organizational reality. Chapter 5 has shown the greater context of PMI’s recordkeeping by examining PMI’s choice of the social epistemology of malaria knowledge and its chosen best practices of antimalarial practices. Through the case studies of PMI’s relationship with two third party entities, the Research Triangle Institute (RTI) International and the Medical Care Development International (MCDI), Chapter 5 has shown how PMI’s use of the WHO-CDC epistemology of malaria and WHO-CDC best practices affect PMI’s recordkeeping.

An organization that manages wicked problems uses recordkeeping to perpetuate an organizational reality. Figure 6.1 presents an abstracted version of the complex system records model. Power and politics within the organization contextualize the recordkeeping within the organization (Cook and Schwartz 2002, 9, 13; Schwartz and Cook 2002). Staff members on the

ground who experience the “true” local reality would capture snapshots of it in the form of a record. The staff members have to filter the complexity of the local reality in records, and their epistemic bias of what is relevant affects the nature of information that they enter into the records. These records externalize the local reality and affect the social construction of the organizational reality within an organization.

Figure 6.1. The complex system records model



This thesis contributes to archival science and biomedical informatics. For the former, this thesis presents an alternative conceptual model and complements other conceptual models of recordkeeping in archival science. The complex system records model is robust and brings to the forefront the key dynamics within an organization. Recordkeeping is one of the ways that an organization perpetuates an organizational reality. For the latter, the complex system records model presents the importance of the epistemology of knowledge that an organization embraces. Knowledge is socially constructed and the epistemology that an organization embraces would create an epistemic bias within the organization. This in turn affects the nature of information that the staff enters into the records. There are more potential applications of the complex system records model to other aspects of recordkeeping, archival science, and biomedical informatics, and future works should apply the complex system records model to organizations that manage other types of wicked problems.

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