The Public Health Information Technology Maturity Index:

An approach to evaluating the adoption and use of public health information technology

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I. Executive Summary

The quality, effectiveness and efficiency of public health services in communities nationwide is critically dependent on effective use of information across local health departments and the network of somatic, behavioral, dental and social service providers servicing the populations. Coordination and information exchange is particularly critical for those populations serviced by the "safety net" of providers that support some of the most vulnerable, disadvantaged, medically complex and socioeconomically challenged individuals.

Public health information technology (PHIT), which is the collection of information systems supporting the pubic health mission that may consist of technologies such as electronic health records (EHRs), population health analytics, surveillance systems, registries, consumer digital resources, administrative systems, health information exchange and related systems, provides unique opportunities for improved integration and coordination within public health systems and across community partners. However, limited evidence and understanding has existed to aid communities in guiding decisions about PHIT investments and strategies in support of public health objectives.

This research is anchored within the fıeld of public health services and systems research (PHSSR) that has emerged over the past decade to develop the evidence needed by public health practitioners and policy makers to improve the nation's public health system (Scutchfield et al. 2007). More specifically, in the context of PHIT, this report describes the development and structure of a new tool, a PHIT Maturity Index, to measure the status of a health department's journey from having basic IT capabilities to a state where IT and supporting processes are leveraged in ever greater value-producing ways to achieve the public health mission (Van Wave, Scutchfıeld, and Honoré 2010), effectively applying technology strategies for public health services, inter-agency and clinical care program communication, integration and optimization.

This report provides detail on the background, methods, and composition of the PHIT Maturity Index and its applicability as a tool for public health assessment, decision support and improvement aims. We acknowledge the many differences that exist across health departments (HDs) such as size, organizational structure, scope of authority, resources, population served, governance, and geographic region, which may make broad comparability using the Index challenging. However, we note that there are common elements regarding HD mission, services, strategies, and target capabilities that provide opportunities to apply the Index in a meaningful way towards the evaluation of their information technology deployment decisions. As benchmark data become available, it may enable comparative assessment and possible linking of IT maturity and multi-agency interoperability to population health outcomes.

This project leverages work with the Montgomery County [Maryland] Department of Health and Human Services and the Primary Care Coalition of Montgomery County conducted in partnership with the Center for Health Information and Decision Systems (CHIDS) at the Robert H. Smith School of Business and the University of Maryland School of Public Health with support from the Robert Wood Johnson Foundation.

II. Background

The Need for PHIT Measurement

Although there is significant national attention on the opportunities that health IT, anchored by electronic health records (EHRs), offers to improve individual patient and population health, limited understanding and evidence exists for the role and potential of health information technology at the intersection of public health, somatic care, behavioral health, dental care and social services. The promise of these technologies to inform and catalyze fundamental changes and improvements in the public health system is significant. EHRs and complimentary public health information technology (health information exchange, data warehouses, epidemiological and surveillance systems, etc.) may be viewed as transformational tools that can address multiple systemic deficiencies in healthcare delivery and population health management, especially in regard to tighter integration of primary care and public health services.

The current regime for primary care and population health management exhibits many opportunities to improve the effectiveness, efficiency and quality of service delivery. The siloed systems that exist in most jurisdictions nationwide lead to an incomplete picture of clients' needs and restrict best practice care coordination and case management practices. Importantly, there is a pressing need to support the integration of primary care and the social determinants of health for individuals, families and communities.

Further, the integration of primary and behavioral health, beyond that which is achievable through co-location, and services that are not constrained by time and location, are needed for optimizing quality and operations. There also exists an opportunity to speed-up cycle time between identification of client needs and receipt of services. Cycle time can be an important driver for improved prevention and management of somatic and behavioral health issues (Shea and Shearn, 2011). Timely access to needed somatic, behavioral and social determinant data is an essential capability of mature PHIT. Better information capture, curation, management, analysis and sharing offered by improved information systems and processes should lead to these advancements in public health services.

This project is responsive to and in concordance with the goals of major cross-sector organizations, including those of the Institute of Medicine (IOM), which seeks to understand how elements of the public health system influence the effective implementation of public health and primary care integration strategies (IOM, 2015). This work is structured to help answer two of the key questions within the PHSSR research agenda that has been advanced by the PHSSR Consortium of the Centers for Disease Control and Prevention, the Robert Wood Johnson Foundation, Altarum Institute, and the National Coordinating Center for Public Health Services and Systems Research (PHSSR Consortium, 2012):

1. How can electronic health record systems, surveillance systems, registries, consumer digital resources and health information exchanges affect the structure of public health delivery systems, particularly regarding integration and coordination across somatic, behavioral and social care providers?

2. How may health information and communication technologies influence the effectiveness, efficiency and outcomes of public health strategies delivered at local, state and national levels?

Prior Work on Information Technology Maturity Indexes

The maturity of any system or process addresses the extent to which it has evolved in response to environmental contingencies and is able to more effectively address the key objectives for which it was originally designed. In the context of information systems and processes, maturity reflects progress from initial adoption to greater value creation. Theories of adoption and maturity of information systems and technologies have received significant attention in the business school literature, notably in the management science and information system disciplines, for over four decades. Early work in the 1970s, particularly Richard Nolan's maturity models (1973, 1979) are generally credited with sparking research into this type of formulaic assessment of an organization's adoption and use of information and communication technologies (ICT).

A maturity model can show the transformation and improvement of an organization over time and the model may be used to establish goals for achieving and measuring progress (Rocha, 2011; Becker et al., 2009; Myers et al., 1997). The model is typically disaggregated into discrete, sequential stages detailing specific characteristics or attributes of ICT adoption, use and structure of the respective stages. Some maturity models describe the critical success factors at each stage (Khandelwal and Ferguson, 1999), while others simply delineate the stages and their characteristics. A maturity model may apply to ICT use broadly, or to specific types of ICT, such as towards ERP systems (Holland and Light, 2001) or software development (CMMI, 2006).

In the healthcare industry, there are multiple examples of ICT maturity models. For over a decade, HIMSS Analytics has supported an Electronic Medical Record Adoption Model (EMRAM), which hospital executives use to measure progress and guide investments in EHR/EMR capabilities. More recently, HIMSS has launched a Continuity of Care Maturity Model, which incorporates seven stages ranging from Limited to no e-Communication (Stage 0) to a Knowledge driven engagement for a dynamic, multi-vendor, multi-organizational interconnected healthcare delivery model (Stage 7). Quintegra, an IT Consultancy, developed "The Maturity Model for Electronic Healthcare" that attempts to show progression from a disconnected immature stage to a [U.S.] nationally interconnected health network with true data liquidity. IDC, an IT-focused research organization, provides a hospital specific maturity model that details stages from a basic Health Information System for capturing data electronically to a fully "Digital Virtual Enterprise". The United Kingdom's National Health Services uses its own maturity model for electronic patient records, which is a 6-stage model focusing on the types of systems implemented, spanning from basic administration and independent departmental systems to advanced multi-media (like Picture Archiving and Communications Systems – PACS) and telematics (such as telemedicine).

In contrast to the adoption and use of ICT in general and EMRs in particular, the maturity of ICT in the specific public health system context has not received as much attention in the literature, but there exists some prior work. Olsen and Baisch (2014) conducted a review of information systems used in local health departments (LHDs) in order to gain a better understanding of the extent to which they are able to communicate data and support public health informatics across a range of activities. Their results indicated a wide array of information systems in use by LHDs, which in general are classified across five categories: administration; surveillance; health records; registries; and, consumer resources. Groups such as the National Association of County and City Health Officials (NACCHO) and the National Opinion Research Center (NORC) have examined public health IT systems, and found challenges to closing the technology gap between public health and health care, such as limited IT funding and shortages of skilled staff (NORC and NACCHO, 2012). The public health system has no comprehensive IT evaluation tool. The Public Health Accreditation Board's (PHAB) "Measures and Standards" contain two standards directly related to information technology, the first (standard 3.2) relates only to transmission of communications to the publics the departments serve, and the second (standard 11.1) addresses the issues of data collection and management, but does not specifically describe how complex systems and data in a community may be leveraged.4 The PHIT Maturity Index is designed to help fill this gap.

III. Methods

How the PHIT Maturity Index was developed

The overall research strategy behind the PHIT Maturity Index draws upon the principles of a mixed-methods approach. We conducted an extensive literature review of past work regarding the maturity of information systems broadly and also within the health care and public health context specifically. Foundational work in public health systems and services research was leveraged for the development of the Index as well. Peer reviewed published literature and reports from credible multi-stakeholder organizations like NACCHO, IOM, and the PHSSR Consortium were included.

This research includes a detailed study of a natural experiment enabled by the public health IT transformation efforts of Montgomery County, Maryland, a large suburban county. Montgomery County has been engaged in on-going efforts to improve public health services leveraging new IT systems. Notably, the Montgomery County Department of Health and Human Services (DHHS) and a public-private network of safety net clinics supported by the Primary Care Coalition of Montgomery County (PCC) embarked on the process of implementing an EHR that supports coordination across Social, Somatic, Dental and Behavioral Health Services. Both qualitative and quantitative data collection techniques were used. We conducted an intensive analysis of this EHR implementation across PCC and DHHS facilities (12), using interviews (61), observations (16), patient focus groups (3) and surveys (55.5% overall response rate) of EHR users before and after the EHR implementation, and client chart reviews (67), which provided a rich qualitative record. A detailed chart review was conducted to enable our understanding of the use, breadth, capability, and usability of both legacy and existing systems. The experiences of implementing PHIT and the factors important to successful value realization were distilled and assessed for Index inclusion. Survey data was analyzed using factor analytic strategies to assess the reliability of subscales and their conceptual structure, and t-tests and multivariate regression provided inferential insights.

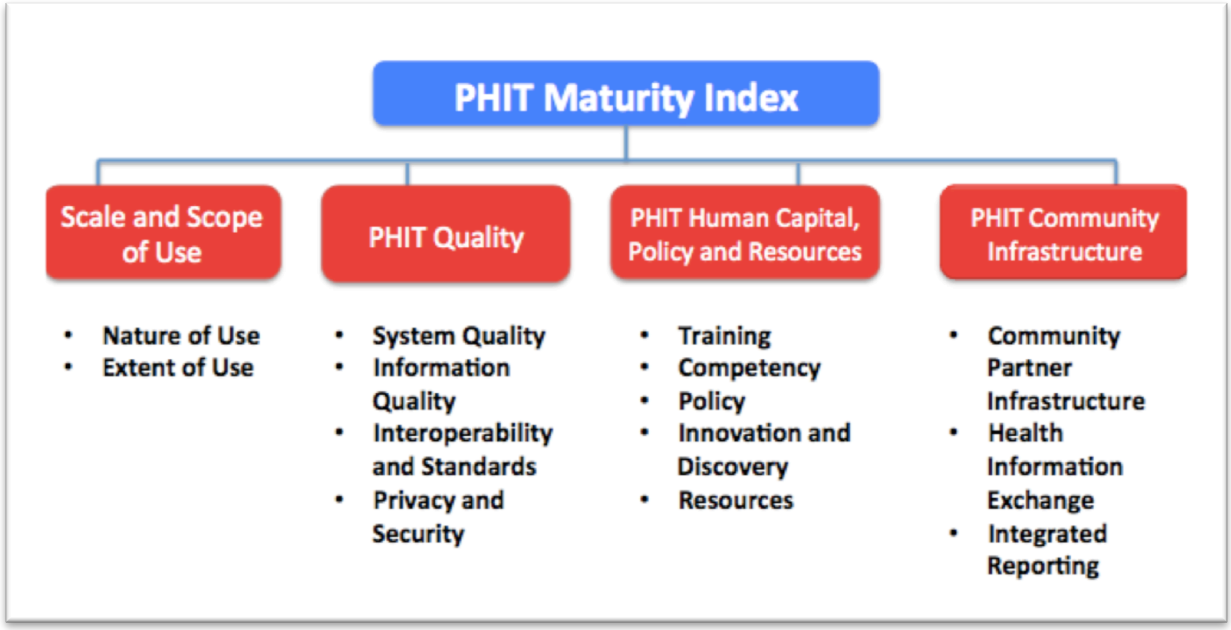
Further, a Delphi exercise was conducted with six experts representing public health systems at the state and local level and multi-stakeholder national groups. The Index design, narrative and corresponding questionnaire received written feedback, followed by a virtual focus group to obtain further feedback. After the virtual focus group, a refined model was distributed for a concluding round of written comments, which were incorporated into the final PHIT Maturity Index.

IV. Index Description and Use

About the Index

The PHIT Maturity Index is designed to help public health stakeholders gauge their position in relation to a set of stages that progressively and incrementally detail better use of information technologies to achieve the public health mission. Over time, as additional benchmark data become available, it should be possible to perform a comparative assessment of a HDs PHIT maturity in relation to other HDs and systems across the country. Figure 1 shows the primary categories and 14 subdimensions of used for assessment.

Figure 1. PHIT Maturity Index



Index Measurement Categories

The following four measurement categories serve as the primary dimensions for the PHIT Maturity Index.

1) **Scale and Scope of Use**

2) **PHIT Quality**

3) **PHIT Human Capital, Policy and Resources**

4) **PHIT Community Infrastructure**

The Index categories and subdimensions are described below. Appendix A provides additional guidance on the measurement and reporting processes and the questionnaire HDs would complete to gauge their level of IT maturity.

Scale and Scope of Use

The Scale and Scope category of PHIT Use captures the types of systems being used, the activities to which they are being applies, and the breadth of system use. The sub-dimensions include the "*Nature of Use*" and "*Breadth of Use*".

The *Nature of Use* refers to the types of systems used and how the information systems are used. There are generally seven categories of information systems currently used (and in the future, to be used) in public health. We add the new capabilities of health information exchange and analytics/business intelligence systems, to the traditional five public health information systems as documented by Olsen & Baisch (2014). The information system types are as follows[1]:

- Administrative
- Surveillance
- Electronic health record and practice management systems
- Registries
- Digital Consumer Resources
- Health Information Exchange
- Analytics and Business Intelligence

The *Extent of Use* subdimension refers to how much use of IT is occurring within the public health services areas of an HD. The extent of use considers both the breadth and depth of IT system usage. Breadth of usage is assessed by measuring the degree to which systems are effectively being used to support the public health mission, leveraging the categories described by the 10 essential services of a public health department as the basis. The National Public Health Performance Standards (NPHPS) instruments (CDC, 2015) define the 10 essential services of a public health department.

[1] Of these seven categories only the first five are represented in the current PHAB Measures and Standards (Public Health Accreditation Board, 2014) Neither "Health Information Exchange" or "Analytics & Business Intelligence" are referenced specifically in those standards.

These essential services are the public health activities that all communities should undertake, and include:

1. Monitor health status to identify and solve community health problems
2. Diagnose and investigate health problems and health hazards in the community
3. Inform, educate, and empower people about health issues
4. Mobilize community partnerships and action to identify and solve health problems
5. Develop policies and plans that support individual and community health efforts
6. Enforce laws and regulations that protect health and ensure safety
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable
8. Assure competent public and personal health care workforce
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services
10. Research for new insights and innovative solutions to health problems.

The Extent of Use also includes the *Depth of Usage*, which is measured by the proportion of the HD workforce that is using PHIT systems. This subdimension reflects the diffusion and assimilation of the systems across the intended user base.

Quality of PHIT

The *Quality of PHIT* category seeks to capture the degree of "excellence" embedded in the PHIT. The four sub-dimensions that collectively contribute to PHIT Quality measurement include:

- System Quality
- Information Quality
- Interoperability and Standards
- Privacy and Security

System Quality in the PHIT maturity index is measured in terms of ease of use, system usefulness, learnability, user satisfaction, reliability, and support services (Davis, 1989; Delone and McLean, 2003). *Information Quality* in the PHIT maturity index is measured by availability of relevant information, information accuracy, information usefulness and timeliness. Higher system quality and information quality contribute to more effective use, including greater individual staff efficiency and overall IT value to the organization (DeLone & McLean, 2003).

The *Interoperability and Standards* sub-dimension measures the extent to which technical standards are available, implemented and adhered to, and the extent of multi-system interoperability. System interoperability is the ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged. The PHIT Maturity Index leverages the Health Information Management Systems Society (HIMSS) definition of interoperability (HIMSS, 2013) ranging from little interoperability, to foundational, structural and at the highest level, semantic interoperability (See http://www.himss.org/library/interoperability-standards/what-is). To ensure there is widespread adoption of PHIT, promoting interoperability among the systems is highly desirable and may well represent a critical barrier to broad PHIT penetration and value optimization (Goldschmidt, 2005). A lack of interoperability can create islands of medical and social determinant information systems that only exchange data with each other and preclude the realization of the social benefits promised by the broad adoption of EHRs. Data exchange schema and standards should permit data to be shared both within public health departments and across partners such as social service agencies, school-based health services, clinicians, dentists, lab, hospital, pharmacy, and patient regardless of the application or application vendor.

The *Privacy and Security* sub-dimension assesses an HDs development and use of privacy and security practices. Security of a computer-based information system should, by design, protect the confidentiality, integrity, and availability of the system (NIST, 1995). Information privacy, or data privacy, is the relationship between collection and dissemination of data, technology, the public expectation of privacy, and the legal and political issues surrounding them. The challenge in data privacy is to share necessary data while protecting personally identifiable information and adhering to regulations, which at times is confounded by policy variance across locales, data types, and other factors. This PHIT Maturity Index dimension evaluates the development and implementation of privacy and security practices, and in the case of privacy, relates to the ability an HD has to determine what data in a computer system can be shared with third parties and being able to consistently share or not share appropriately.

PHIT Human Capital, Policy and Resources

It is widely acknowledged that the realization of value from ICT is critically dependent on the skills and capabilities of users. The human capital sub-dimension, refers to the set of skills and knowledge that are essential for the public health workforce to have productive interactions with technology-based tools (Watkins & Xie, 2014). It also captures the existence and effectiveness of courses, curriculum or other training to prepare for PHIT implementation and improve the PHIT competency of the workforce on an ongoing basis (Peña-López, 2010). Measures are provided for the development and use of PHIT training programs and whether the workforce and network partners have developed competency in using PHIT, respectively.

This category also encapsulates the development and implementation of the necessary legal/policy instruments for successful PHIT use. Because the health record is a legal business record for the organization, it must be treated in a method that adheres to applicable regulations, accreditation standards, professional practice standards, and legal standards. Policy standards may vary based on care setting, legal jurisdiction and locale. Examples of policies related to PHIT that need to be developed in support of a well-functioning and compliant public health system include (AHIMA, 2007):

- Defining the legal health record and standards for maintaining the integrity of the record content
- Transition to electronic health records
- Business continuity planning
- Down time procedures
- Electronic sharing of clinical information with other organizations
- Ownership of the electronic record
- Records/information from others facilities and providers
- Amendments to the electronic record
- Use of community Health Information Exchange

The Index measures the degree to which these policy mechanisms have been defined and implemented. This subcategory also measures the extent to which policies and corresponding technology and processes have been instituted to support open data innovation and public health research using HD data. Community engagement, policy development and evaluation, informing and educating, are public health goals closely tied to open data and research support mechanisms with PHIT.

The third and final subcomponent of PHIT Human Capital, Policy and Resources category is the Resources, and this measures the extent to which adequate financial support is available to support the PHIT needs of the HD.

Community Digital Infrastructure

The fourth and final PHIT Maturity Index measurement category is PHIT Community Infrastructure, which refers to how "wired" a community is. The Community Digital Infrastructure category evaluates *Community Partner Infrastructure*, which refers to the IT capabilities of partners in the public health ecosystem, notably the hospitals, that are complementary to the HD and the partners' ability to exchange information electronically with the HDs. The public health system data and coordination partners extend beyond just hospitals, and may include:

- General family medicine clinics
- Specialists clinics
- Laboratories
- Pharmacies
- School-based clinics
- Nearby jurisdictions
- State reporting systems
- Federal reporting systems

The level of *Health Information Exchange Use* with the HD is also evaluated in his category, as increasingly, research shows HIE benefit across various public health use cases (Dullabh, Ubri, & Hovey, 2014), although we note many communities are yet to reach sufficient adoption across partners to fully harvest the potential benefits.

The ability for *Integrated Reporting* by state systems is also assessed in this category, for while a local HD may implement automated data reporting capabilities, if the receiving entity has not enabled this capability, the HD cannot take advantage of these efficiencies. For example, many states have created automated immunization reporting from EHRs, but several states have not reached this stage of development for more efficient immunization reporting.

Measuring Maturity

Within the four high-level PHIT Maturity Index categories (Scale and Scope of Use; Quality of PHIT; PHIT Human Capital, Policy and Resources; and, PHIT Community Infrastructure), the items are weighted for computing maturity level. *Scale and Scope* is equal to 35% of total weight, *PHIT Quality* equal to 30%, *PHIT Human Capital, Policy and Resources* equal to 20%, and *PHIT Community Infrastructure* equal to 15%, respectively. A greater weight is given to the first two categories as HD's have the most control over these measures (e.g. an HD can purchase EHRs, but has less influence

over community partners adoption of ICT). Appendix A provides greater detail on the methods for completing the Index questionnaire and evaluating maturity accordingly.

The source of data to answer each sub-dimension will come from a mix of questionnaire and secondary data. Appendix B lists potential sources of data to compute the Public Health IT Maturity Index measures.

VI. Conclusions and Future Work

The PHIT Maturity Index represents a potentially useful approach and toolset to aid public health system stakeholders, notably HD's, in the evaluation of their technology-mediated strategies to improve the quality, effectiveness and efficiency of public health services. PHIT provides unique opportunities for improved integration and coordination within public health systems and across community somatic, behavioral, dental, social determinant and other service providers. However, incomplete evidence and understanding has existed to-date to aid communities in guiding decisions about PHIT investments and strategies. The PHIT Maturity Index is a tool that offers more evidence-based assessment and guidance regarding PHIT implementation and use. Over time, as additional benchmark data become available, it will enable a comparative assessment of PHIT maturity in relation to other similarly structured HDs and systems across the country and one could longitudinally link outcomes to better understand which PHIT configurations and services may offer the most value for individual public health system types across different regions and need scenarios. There may also be an opportunity to align the PHIT Index to goals of the Public Health Accreditation Board (PAHB) to extend the breadth of accreditation review.

Appendix A. Completing and Scoring the PHIT Maturity Index

The PHIT Maturity Index is provided foremost as a resource for health departments. We recognize there is a high degree of variability across health departments, such as by size, budget, geography, services, structure, etc., however, the tool is aimed to be generalizable to any HD. Any HD may use the tool for assessment, and for HDs with similar attributes, comparison of position across peer HDs may prove instructive for benchmarking and planning.

We also recognize that public health systems extend beyond the health department, and may be defined as "all public, private, and voluntary entities that contribute to the delivery of essential public health services within a jurisdiction definition." Elements of the interoperability and community infrastructure are thus embedded within the scoring and to some extent, certain scoring is dependent on capability of public health system network partners, such as hospitals or an health information exchange, for example.

Completion of the index questionnaire is situated within the HD, but may require the input of multiple groups depending on a HD's composition. It is recommended the director of the HD act as the primary authority for completing the questionnaire, but necessarily may require input from IT management, human capital management, legal / compliance authority, and service area management, for example. Portions of the questionnaire require an understanding of staff competency and IT system perceptions, such as staff satisfaction with the IT systems.

The questionnaire consists of 55 questions across the 4 categories. Further detail regarding the scoring methods is provided below.

Scoring methods for the Index:

Each of the 55 questions consists of four multiple choice answers corresponding to each stage of maturity and scored at 1 point at level 1, 2 points at level 2, 3 points at level 3, and 4 points at level 4. The points for each category are totaled then divided by the number of questions in the category to produce the average score in each category ranging from 1 to 4. The average category score is multiplied by the weight of that category to produce a total weighted category score, and the four weighted category scores are summed for a total score.

The category weights are as follows:

Scale and Scope of Use: 3.5
Quality of PHIT: 3.0
PHIT Human Capital, Policy and Resources: 2.0
PHIT Community Infrastructure: 1.5

The ultimate score total generated by summing the weighted average scores of the categories results in a number from 10-40. The scoring bands to approximate the PHIT Maturity Index level are:

Level 1: 10-14 points
Level 2: 15-24 points
Level 3: 25-34 points
Level 4: 35-40 points

While a total score may be an instructive approximation, each category and each question should be reviewed independently to understand positioning of the HD along the specific subdimension elements as a way to assess the current status of IT development, benchmark with peers, set specific goals for progress, and foster a cycle of continuous improvement.

The questionnaire, practitioner guide and additional resources are available online at: http://go.umd.edu/phitmaturityindex

Appendix B. Potential Sources of Measure Data

Categories	Sub-Dimensions	Primary Survey Data	Secondary Data
Scale & Scope	Nature of Use	★	
	Extent of Use	★	
Quality	System Quality	★	
	Information Quality	★	
	Interoperability & Standards	★	★
	Privacy	★	★
	Security	★	★
PHIT Human Capital, Policy and Resources	Training	★	
	Staff Competency	★	
	Partner Competency	★	
	Legal/Policy	★	★
	Open Data Innovation	★	
	Research Support	★	★
	PHIT Resources	★	★
Community Infrastructure	Community Partner Infrastructure	★	★
	Health Information Exchange	★	★
	Integrated Reporting	★	★

Appendix C. Subject matter experts participating in Delphi exercise[2]

Uma Ahlwalia, MHA, Director, Montgomery County Department of Health and Human Services

Alina Baciu, Ph.D., MPH, Sr. Program Officer, Institute of Medicine

Bruce Cohen, Ph.D., Director (ret.), Division of Research and Epidemiology, Bureau of Health Information, Statistics, Research and Evaluation, Massachusetts Department of Public Health

Kim Gearin, Ph.D., Senior Research Scientist, Minnesota Department of Public Health

Joneigh S. Khaldun, MD, MPH, FAAEM, Chief Medical Officer, Baltimore City Health Department

Russ Montgomery, Ph.D., Director of Population Health at Maryland Department of Health and Mental Hygiene

[2] Written comments only: Joseph Gibson, MPH, PhD, Chair of NACCHO's Informatics Workgroup and Director of Epidemiology for the Marion County (IN) Public Health Department.

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