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Report of the AMIA EHR 2020 Task Force on the Status and Future Direction of EHRs

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Over the last 5 years, stimulated by the changing healthcare environment and the HITECH Meaningful Use (MU) EHR Incentive program, EHR adoption has grown remarkably, and there is early evidence of benefits in safety and quality as a result.[1,2] However, with this broad adoption many clinicians are voicing concerns that EHR use has had unintended clinical consequences, including reduced time for patient-clinician interaction,[3] transferred new and burdensome data entry tasks to front-line clinicians,[4,5] and lengthened workdays.[6,7,8] Interoperability between different EHR systems has languished despite large efforts.[9,10] These frustrations are contributing to a decreased satisfaction with professional work life.[11,12,13] In professional journals,[14] press reports,[15,16,17] on wards and in clinics, we have heard of the difficulties that the transition to EHRs has created.[18] Clinicians ask for help getting through their days, which often extend into evenings devoted to writing notes. Examples of comments include "Computers always make things faster and cheaper. Not this time." and "My doctor pays more attention to the computer than to me."

Ultimately, our goal is to create a robust, integrated, interoperable health system that includes patients, physician practices, public health and population management, and support for clinical and basic sciences research. EHRs are an important part of this ecosystem, along with many other clinical systems, but future ways in which information is transformed into knowledge will likely require all parts of the ecosystem working together. This ecosystem has been referred to as the "learning health system."[19] Potentially every patient encounter could present an opportunity for patients and clinicians alike to contribute to our understanding of health care and participate in research and clinical trials.

As part of the learning health system, EHRs have long been touted as beneficial to the safety and quality of health care, and studies have shown potential benefits related to information accessibility, decision support, medication safety, test result management, and many other areas.[20,21] However, implementation of any new technology leads to new risks and unintended consequences; these too have been well documented.[22,23,24]

Much of the focus of the last decade, via MU and other incentives, was to encourage providers and other health professionals to implement EHRs and use them to capture and share data important to quality and cost. The work now ahead is to ensure that these systems are designed and implemented in a way that yields promised benefits to efficiency, quality and safety with fewer side effects.[25] While cost, usability, and other considerations are important, patient safety and quality of care need to guide how we optimize these systems.

There can be a tension between efficiency and safety. Medication reconciliation is a good example—medication errors at transitions of care are a significant safety concern and represent a rationale for adding safeguards despite the impact on time and process.[26] EHRs now include detailed processes to reconcile medications that some providers feel add to their workload and slow them down. Informed by careful studies,[27,28,29] tradeoffs do need to be made to strike the right balance. However, there are many ways to optimize both safety and efficiency and this is the goal of the recommendations of the AMIA EHR 2020 Taskforce.

As the professional home of health informatics professionals, AMIA is well qualified to address many of the health IT challenges from a wide range of perspectives. AMIA members include informaticians, clinicians, scientists, vendors, innovation and implementation scientists, change agents, and people who cross all these boundaries; our members develop, implement and study ways to manage information for patients, for professionals in their clinical practices, for public health and for clinical research. Within EHR activities, AMIA members have developed, implemented, studied, and refined EHRs, and advocated for their broader use for nearly 40 years. AMIA has recently addressed electronic documentation[30] and usability[31] because of the importance of these areas to EHR success. The AMIA Board of Directors chartered the multidisciplinary EHR 2020 Task Force to develop recommendations on how we can resolve the EHR issues that have been raised.

While EHRs are a critical part of the learning health system, this report focuses only on near-term strategies to address

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current challenges in EHRs and does not address other areas of the learning health system. The future of EHRs will very likely involve many changes as health care itself changes through greater incorporation of genomic information,[32] rising involvement of people in their own care,[33] evolving reimbursement models[34] and in other ways. Our report focuses on some but not all of this future; we concentrate on issues of greatest concern to those using EHRs today and on directions for the next five years while setting the stage for future innovation.

When and where do we start addressing these problems? We start now and with 10 recommendations in five areas:

I. SIMPLIFY AND SPEED DOCUMENTATION

Recommendation 1. Decrease data entry burden for the clinician. Although medicine requires an entire team to care for patients and to document the care patients receive, interpretation of CMS' requirements has placed the primary burden of office visit documentation on physicians. Information entered by other care team members and patients should be as valued as that information entered by the physician. Much of the information relevant to the diagnosis and treatment of a patient could more effectively be entered by other members of the care team, captured automatically by devices or other information systems, or captured and entered by patients themselves.[35,36,37]

Physicians' time investment in documentation has doubled by some measures in the last twenty years, and may consume up to half of a physician's day.[38,39] Time requirements for nursing documentation have also changed as has documentation workflow.[40] This growth in documentation burden was associated with changes in Medicare reimbursement rules,[41] possibly overly strict interpretations of those rules by compliance officers,[42] concerns about malpractice litigation, and other factors. The introduction of EHRs has magnified these problems and the amount of time providers spend in documentation. In a large survey, staff internists reported that EHRs take an extra 48 minutes per day of their time compared to their manual systems and entry of visit notes into the computer garnered the strongest complaints from the most respondents.[6] A large RAND survey documented analogous complaints.[43] To reduce the time cost of the EHR, some providers use "copy and paste" options to insert information from past notes, review of systems and laboratory results into their current note. This practice has caused its own set of problems,[44,45,46,47,48] including bloated visit notes, which can obscure the providers thinking and key facts about the patient, and inaccurate editing that yields incorrect or nonsense text[49] both of which raise concerns about patient safety. Comments from providers include: "The notes are all cookie-cutter, unreadable," and "Everyone's notes are 5–8 pages long and who has the time to read them?"[50]

Clinicians remain uncertain regarding who can and cannot enter data into the record, placing a tremendous data entry burden on providers, the most expensive members of the care team. Clinician time is better spent diagnosing and treating the patient rather than charting. Regulatory guidance that stipulates that data may be populated by others on the care team including patients would reduce this burden.

Recommendation 2. Separate data entry from data reporting. Data can be entered by the patient, family members and the care team, and then used in multiple ways to generate customized reports, including formal visit notes, letters to referring providers, billing records, and quality assessment programs.

Templates are often used to capture data as discrete observations in place of free-text narratives. The resulting documentation sometimes has limited relevance to the visit being documented; yet important aspects of the patients' stories can only be effectively captured by narratives. Compared to human narrative, purely coded templates do not distinguish the informational wheat from chaff nor do they capture the subtle special circumstances of each patient. Further, coded templates are a disservice to the communication needs of clinicians.[51] With natural language processing we might have accurate and human-digestible narrative as the primary input with computer-understandable discrete data as a by-product. Progress in real-time natural language processing can reduce reliance on templates,[52] and should be bolstered. Vendors should enhance their patient portals to support data collection from the patient and increase support for multiple modes of data entry to accommodate provider preferences including voice, typing, clicking, and handwriting recognition.

Documentation requirements go beyond note writing. Manual entry of encoded data needed to track preventive and chronic illness care requires time, and this often falls to providers at the point of care. Policymakers should encourage fully standardized interfaces between IT systems rather than manual labor to deliver clinical data from medical devices and other external sources. Lab interfaces are widely available, but the standardization of test codes (LOINC) needed for automatic filing has only begun. Radiology, electrocardiography, cardiac echocardiography and other diagnostic systems also have interfaces, but policy has not yet required the standardization needed to deliver these results automatically into EHRs. MU now allows for medications, allergies, and problems to be discretely imported, but much of what could be encoded is still delivered as text. Expansion of bidirectional immunization registries will allow for populating the immunization record (with clinical validation where appropriate), relieving the burden of manual re-entry.

We applaud the efforts to move to value-based purchasing. Less prescriptive and more flexible requirements for documentation will focus attention on outcomes and clinical relevance, and will speed the adoption of better ways of capturing and documenting clinical care.

Recommendation 3. EHRs should enable systematic learning and research at the point of care during routine practice, including a better understanding of the costs (in time) and benefits (to care delivery, research, and billing) of different approaches to capturing and reporting clinical data. The Agency for Healthcare Research and Quality (AHRQ), the National Institutes of Health (NIH), the Patient-

Centered Outcomes Research Institute (PCORI), the National Institute of Standards and Technology (NIST) and others should support studies of the usage and unit-time cost of each additional required data collection item and the effect of different collection mechanisms such as typing, menu selection, drawing, voice understanding, natural language processing, hand writing and hand writing recognition on the time to enter and the usability of such information. These federal entities should encourage and support the study of alternative approaches and media that could be more efficient of provider time, such as by sound recording of the history and physical and patient advice portion of the visit instead of writing it all down.[53,54]

Health services researchers often look at cost effective strategies for improving patient care and evaluating proposed therapies. As a result, they have developed sophisticated ways of assessing whether an intervention meets a cost effectiveness threshold and should be recommended for broader use. We need similar studies to understand the cost and benefits of proposed data items to be recorded in the EHR. We should build on studies of the time and effort required to enter documentation and its relation to clinical team efficiency.[55,56,57]

In addition to enabling the incorporation of research knowledge into practice to support evidence based medicine (EBM), EHRs can enable evidence generating medicine,[58] thereby creating a virtuous cycle of rapid evidence generation and evidence-based care delivery, an essential element needed to create a LHS and to advance precision medicine.[59] Examples of such activities at the point of care might include: (a) facilitating the identification and recruitment of potential research subjects during practice such as through clinical trial alerts directed at clinicians or patients; (b) enabling adherence to research protocols during practice; (c) enabling easy and customizable data collection approaches unique to research during patient encounters that have both research and clinical purposes. This should be accomplished without adding burden to the complexities of physician/clinician interaction and begs for additional innovation.

II. REFOCUS REGULATION

Recommendation 4. Regulation should focus on 1) clarifying and simplifying certification procedures and MU regulations, 2) improving data exchange and interoperability, 3) reducing the need for re-entering data, and 4) prioritizing patient outcomes over new functional measures. Regulatory guidance should be provided to local carriers[60] so that vendors and providers can work together to streamline workflows, relieve data entry burden, promote innovation, and thereby enhance usability of EHRs.

Clarifying and simplifying certification and MU regulations

The first three years of the EHR MU Incentive Program stimulated dramatic increases in EHR adoption and use. More than 3800 ambulatory and 1200 inpatient developers and vendors brought products to market under the Office of the National Coordinator for Health Information Technology's (ONC's) 2011 Edition program for Certified EHR Technology (CEHRT). Despite significant cost and effort to implement EHRs, the majority of Eligible Providers, Eligible Hospitals, and Critical Access Hospitals were able to successfully achieve MU Stage I. Additional requirements have been added to the 2014 certification program. Fewer vendors are providing certified products and some eligible providers have dropped out of the program. This outcome has led to a flurry of regulatory responses with exceptions, flexibility, and extended attestation periods. It has also led to proposed legislation to increase flexibility in the program. These changes suggest that the EHR incentive programs should take a different approach to leverage the gains already made and prevent further erosion of the program.

To comply with MU requirements, vendors have diverted resources away from client-requested enhancements, efforts to streamline workflows and enhance usability, and innovation in general. We believe that the 2014 Edition CEHRT has the necessary foundation of EHR functionality that will set the stage for better data exchange and interoperability, simplified workflows and data entry, and will support a quality and patient outcomes focused EHR. Future editions should focus on simplifying the certification process while supporting improvements in interoperability, clinical quality measures, safety and security. Holding fast on existing attestation requirements will allow Eligible Providers, Eligible Hospitals, and Critical Access Hospitals to meet meaningful use requirements while they upgrade their EHR systems in a timely fashion with adequate testing and training prior to taking the upgraded products live. It will allow time for EHR users and vendors to stabilize their products and improve workflows and usability.

Improving data exchange and interoperability

New certification requirements should focus on technical requirements that will improve interoperability and data exchange, support better quality measures, and provide for safer and more secure care. Additional regulations should focus on reducing barriers to interoperability and efficient data flow. For example, the use of the standard code set that exist for laboratory and radiology test orders could save time and money in their respective information system interfaces.[61] Data registries for quality, immunizations, research data, or syndromic surveillance could benefit from EHR standards for data and for code sets and could reduce the cost of interfaces between different systems. Reducing costs of interfaces may lead to new business models funded through business interests or public good.

Reduce data entry and focus on patient outcomes

Quality measurement and reporting should focus on outcomes that are consistent with national priorities while also being relevant to clinicians' specialties, patients and communities. Data collected should only include those necessary to diagnose and treat the patient's condition and not add to the documentation burden. EHR users should not have to implement functionalities or document findings where the main benefits do not accrue to the patient or practice but rather to others such as payers or other secondary data users. Changes in regulation that make it

much easier to report accurate and meaningful quality measures are important given the prospects that outcomes attributed to providers and hospitals will be made publicly available.[62,63] Working with payers and other stakeholders to develop payment alternatives that depend less on documentation and more on quality and value is likely to promote EHR innovation and uses that support these goals. [64,65]

Recommendation 5: Changes in reimbursement regulations should support novel changes and innovation in EHR systems. We applaud changes to payment models as well as federal guidance designed to accommodate innovation in health information technology.

Meaningful Use incentives have accelerated use of health information technology and have increased documentation to track individual clinical outcomes, including electronic clinical quality measures. The CEHRT program has supported the standardization of this documentation, helping ensure the potential for future semantic interoperability. EHRs have evolved to facilitate documentation to support billing requirements in addition to documentation needed for care. The current evaluation and management (E/M) coding requirement of capturing bullet points has led to constrained notes that target billing requirements. Generally vendors have used check boxes and radio buttons to facilitate the calculation of coding points. This format optimizes support for billing, but does not result in a note that easily conveys the essence of the visit. In addition, the patients voice (the informant) is rarely captured in the documentation except through the patient's health care team.

Reimbursement requirements influence and are integrally intertwined with EHR design. Moving away from the current E/M billing structure would free EHR developers to support more novel methods to collect data. MU 2014 requirements for a secure patient portal provide new opportunities to collect patient completed data in advance of the visit saving documentation time but more importantly allowing the provider to focus on the patient's priorities for the visit rather than following a prescribed pathway for the patient's conditions.

Reimbursement regulations are changing with health care reform. Pilot programs include an increased emphasis on outcomes including a reduction in disparities in access to health care for the individual patient as well as for the population served. These goals necessitate new EHR documentation and reimbursement models. They focus on team-based care, which requires changes in order entry to facilitate guideline- and protocol-based order sets. Proposed new rules from CMS may dramatically change the nature of financial incentives in Shared Savings Programs. New reimbursement models can help facilitate and support the integration of novel technological ways to deliver and document care for patients and populations.

There is a natural tension between using EHR systems to guide and document care, and to provide adequate documentation to ensure appropriate reimbursement. Continued requirements to support E/M codes will slow progress toward new ways of defining the medical record, acquiring and integrating data, and supporting clinical documentation and the decision-making process. Working together with CMS and other payers, is essential to ensure that the EHR of the future can fulfill the need for comprehensive, usable documentation as well as reimbursement.

III. INCREASE TRANSPARENCY AND STREAMLINE CERTIFICATION

Recommendation 6. In order to improve usability and safety, to foster innovation and to empower providers and EHR purchasers, how a vendor satisfies a certification criterion, such as for the CEHRT program, should be flexible and transparent. To inform the market and to enhance competition among vendors, additional data about the certification process should be made available. This could include video recordings of the certification processes demonstrating how each vendor satisfies each certification criteria, detailed data and information models for APIs, and how data are entered and extracted from the EHR as part of the certification process. These resources should be made available to the public on the certification body's website.

In order to provide vendors with clarity on how to meet the MU certification criteria, ONC provides precise instructions for each MU functional objective. The advantage of this approach is that vendors know with certainty how to qualify for MU certification. An unintended consequence is that vendors believe their customers must follow the workflow they programmed into the certified function and built into the automated calculation of the MU threshold determination. This predetermined workflow built into EHR products significantly affects usability of the products, often in a negative way.

We recommend that ONC provide less prescriptive instructions for meeting MU certification, and work with the vendors, informatics professionals and the industry to develop clear, flexible, and transparent methods for testing whether the product meets the MU functional objective. Clearly stating the goal of the testing method, creating flexible methods of reaching those goals, and then making sure that the testing approach can be reviewed by customers would provide testing solutions that meet the needs of both vendors and customers. For example, a testing body could record the process of demonstrating that a product meets the MU functional objective and to post the recording on the certification body's public web site. Additional resources that would help a customer make informed decisions could include posting of public APIs, information models, and the steps taken to record data into the system, or to get data out of the system. This would ensure integrity of the process and also inform the market about the usability of the vendor's implementation of the MU functional objective.

Currently, purchasers of EHRs often do not have visibility into how applications work. This lack of transparency inhibits an effective, competitive marketplace. Those choosing EHRs need clear knowledge of what commercial EHR systems offer and, importantly, what workflows are incorporated into their use for frequent tasks such as creating notes, entering data, reconciling medications, responding to decision support, and extracting data for reports or research—so they can make

more informed choices. There are interests in protecting intellectual property that need to be balanced with encouraging competition and an open marketplace, but greater transparency will ultimately help everyone. An informed market would have the effect of enhancing completion, empowering consumers, and stimulating innovation.

Recommendation 7. In order to improve usability and safety and to foster innovation, health care organizations, providers and vendors should be fully transparent about unintended consequences and new safety risks introduced by health information technology systems, including EHRs, as well as best practices for mitigating these risks.

There is much evidence that health information technology can improve patient safety, but there is also evidence that these systems can introduce safety risks and other unintended consequences,[66] such as wrong patient errors, copy and paste errors, and alert fatigue. These issues can arise anywhere in the sociotechnical model,[67] from inadequate software to inadequate policies to poor implementation. Appropriately, many vendors, hospital systems and ambulatory practices have developed ways to mitigate these kinds of issues. However, this information is not frequently shared, so organizations are constantly reinventing the wheel on how to improve.

Vendors, health care organizations and providers should not be competing on safety. Instead, they should be sharing identified problems and sharing ways to prevent or mitigate them. To facilitate information sharing, vendors and health care organizations should work with Patient Safety Organizations to share information about safety issues and best practices. All relevant data related to patient-safety risks (workflows, screenshots, data definitions, code sets, etc.) should be shared with these organizations so that all parties involved can better understand and mitigate safety risks.[68] We support the recent Food and Drug Administration Safety and Innovation Act (FDASIA) report that recommends a public-private partnership in creating a national Health IT Safety Center that would promote health IT as an integral part of patient safety with the ultimate goal of assisting in the creation of a sustainable, integrated health IT learning system.[69]

IV. FOSTER INNOVATION

Recommendation 8. EHR vendors should use public standards-based application programming interfaces (APIs) and data standards that will enable EHRs to become more open to innovators, researchers and patients. These standards should support extension and innovation from both the academic informatics community as well as from innovators inside and outside traditional health IT communities. Access to EHR data and functionality will drive innovation and research into better systems and empower patients to engage in their care. The public APIs and data standards should be consensus based, transparent, well documented, and openly available in a fair and non-discriminatory way.

Pioneering advances in clinical informatics have historically come from academic medical centers with associated informatics programs as well as from vendors and other sources. Today's EHRs benefit from innovations from academic centers and elsewhere 30 years ago, including functionality, data standards and even operating systems. However, nearly all of those academic centers are now switching to commercial EHR products, most of which are closed source, potentially restricting the ability to do informatics research and innovative pilot studies based on commercial EHRs and the data they contain

Similarly, the comprehensive, longitudinal information needed for precision medicine or other national priorities is difficult and expensive to extract from EHRs. This problem is not limited to research use; patients do not have the ability to take their comprehensive longitudinal record (clinic visits, laboratory and pathology reports, operative and radiology information and patient generated information) from one system to another or to use the information for their own purposes.

New methods must be developed that can continue to tap the research capacity of academic informatics centers and encourage the creativity of researchers and innovators who wish to participate in and advance the broad health IT ecosystem. This is particularly important in light of the US government's Precision Medicine Initiative, which will require the ability to capture, store, and present increasingly meaningful molecular information specific to patients and to leverage that data for decision support and other uses. We need a broader ecosystem of innovators to help solve workflow and functionality gaps faced by current EHR users, with opportunities attractive to venture capitalists, academicians, private equity firms and entrepreneurs with creative ideas and willingness to take risks in the marketplace. In short, we believe that EHR vendors should become more open to both extracting data from the EHR as well as creating novel ways to interact with externally defined applications. To get there, we need APIs, data element standards and other ways to efficiently extract data and interact with commercial EHRs. Recent projects using the Health Level 7 Fast Healthcare Interoperability Resources (HL7 FHIR) standard have demonstrated the promise of such open and standards-based approaches that leverage existing web-based technology. [70,71,72]

To that end, we strongly endorse the recent recommendation of the JASON Report[73] and the JASON Task Force (JTF)[74] that the Health IT community should broadly support public APIs as core functionality to support data access. We agree with the JTF that these public APIs must be based on open, consensus-based standards (e.g., HL7's FHIR),[75,76] but must also be widely deployed and exposed to a wide variety of independent innovators in a fair, reasonable, and nondiscriminatory way, such that new ecosystems of innovation can emerge. We believe that in order for these public APIs to be widely implemented, they should eventually become a component of the CEHRT program as the standards mature.

As the learning healthcare system evolves, we will want data access to include methods for more than just providers. Patients can be empowered to interact with data, either through APIs or through data standards that support the extraction of their own longitudinal record. Experience with the Blue Button initiative suggests that access to patient data in a

standardized way will drive and facilitate development of mobile health applications that can help bridge gaps, enhance communications, and facilitate greater interaction between providers and their patients. We foresee the day when prescribing an "app" as part of a care plan and incorporating app-generated data into a treatment record and subsequent care plans will be a routine occurrence. Patient access to these data will empower consumers to support national initiatives such as precision medicine.

The academic research community will also benefit from standardization around the public APIs and the accompanying data standards. Interoperable data element definitions or common data elements (CDEs) used by public APIs will reduce the data mapping burdens that complicate current data aggregation for research use. We believe that widespread availability of public APIs will lead to emergence of new data-sharing networks focused on research uses.

There have been demonstrations that use APIs and have involved commercial EHR vendors and academicians where apps have been able to upload data from a commercial EHR, perform an operation such as decision support, and return messages to the EHR.[77] We hope these encouraging results will be the first steps toward developing an ecosystem that supports health care apps that will eventually import data from and export information to multiple EHRs. EHRs should also leverage innovations that occur outside the walls of health IT, just as other applications benefit from external resources they use but did not create, such as map services and GPS.

V. THE EHR IN 2020 MUST SUPPORT PERSON-CENTERED CARE DELIVERY

The EHR is a shared record between the patient, the care provider teams and the institutions that pay for and provide care. As a result, EHR technologies must be able to evolve at the same pace as changes in the culture of care delivery. To accomplish this goal, AMIA recommends the following:

Recommendation 9. Promote the integration of EHRs into the full social context of care, moving beyond acute care and clinic settings to include all areas of care: home health, specialist care, laboratory, pharmacy, population health, long-term care, and physical and behavioral therapies. We need a record of care that provides views that can vary the timeline, the level of aggregation and abstraction, the scope ranging from the problem to the entire sociocultural context, and the point of view of the user. The ability to incorporate data from different sources is essential. Including patient-generated data, population data and community contexts into an EHR will spur development of new care delivery models, improve population health, aid in the development of precision medicine and support other healthcare transformations.

At one end of the precision medicine spectrum are the patient's social, environmental, and functional contexts. Person-centered care must gather, represent and integrate a patient's social context, functional information, goals and population-relevant information. Although functional status has been shown to be a key predictor of clinician's decision-making in many areas,[78] it is extremely difficult to access. Social data may often be key to accurate decision making,[79] but the data are often widely distributed or simply absent.[80,81]

At the other end of the precision medicine spectrum is the patient's molecular profiling data. With ever-decreasing costs of sequencing technology, patients' genomes are likely to be sequenced routinely in the course of clinical care in the not-so-distant future. The Precision Medicine Initiative[59] is initially focused on cancer, but other disease areas will come into focus as researchers learn more about their underlying molecular dysregulation. Pharmacogenomics (the study how genes affect a person's response to drugs) and the study of congenital diseases are two other areas that are already reaping the benefits of genetic sequencing. While other "omic" biomarkers—e.g., proteomics, metabolomics, and epigenetic signatures—are less mature, these additional types of data may quickly emerge as important data sources.

Patient-centered medical home (PCMH) models of health care delivery are being promoted as core to the future of the US health care system. [82] The EHR adds substantial capability to any PCMH system.[83] EHRs in the immediate future need to support the PCMH principles of care, i.e., care that: 1) is personal, continuous and comprehensive, 2) provides teams with shared awareness of the patient's situation across settings and time, 3) supports a whole-person perspective where the patient's context and life-story is available and integrated across the record; 4) supports enhanced coordination so care can be tracked, monitored and followed through time, 5) integrates evidence-based practice deep into the patient's record through decision support and quality improvement tools, and 6) expands access to care through the use of flexible tools that facilitate enhanced patient-provider communication, expanded hours, and the sharing of culturally specific information.

Manifesting this vision requires much more than simple interoperable platforms, but a new conceptualization of the nature of health care data. Abstracted and summarized patient data should be available and configurable for different goals across a myriad of views. The principles of person-centered care can be much enhanced with the integration of new systems, such as smart phones, biometric sensor information, genomics, big data, etc. Many of these technologies have improved the way that our society travels, buys goods and services, communicates, educates and informs. Although there are technologies and services poised to encourage consumers to interact with their own health data (Fitbit, Apple HealthKit, 23andMe, etc.), they lack integration, usability and ubiquity in the health care domain.

A taste of what is possible in health care has been presented by the ONC's Blue Button campaign.[84] Supported by data standards, the Blue Button has shown that access to data can drive creativity and involvement between patients, providers and developers. Today it is possible for consumers and patients to integrate mobile, video, e-mail, sensor and other technologies into their EHR record. But while it is possible, it is not yet easy or ubiquitous due to impediments such as

proprietary datasets, unique coding configurations, inaccessible siloed information, data duplication and integrity problems, and a lack of data governance structure. Ultimately, an EHR does not stand alone in the equation of what is necessary to realize the vision of true interoperability. The core functions, however, should be focused on the benefits that they provide to patients—direct benefits in the case of the acute and ambulatory settings and indirect benefits in the case of research and public health. Efforts such as PCORI need this functionality in order to realize their missions. Without new payment models or research providing the impetus for change, change will not occur. In the near term, because there has been no incentive to change the status quo, there is now a disconnect between the promise of what we can do and the real-world infrastructure required to actually make it operational and scalable.

Recommendation 10. Improve the designs of interfaces so that they support and build upon how people think (i.e., cognitive-support design). These designs would include empirical findings from such areas as human factor engineering as well as traditional social sciences (anthropology, psychology, sociology, and economics.)

Usability is a real science and goes beyond screen design.[85] Safe and effective EHRs must support person-level customization that addresses such factors as level of expertise, scope of responsibility, and task assignments. These designs must also incorporate institutional guidelines and population-level data into a useful, ergonomic package. Although we know that experts use automatic cognitive processing, we have not designed information displays to support our pattern matching abilities with minimal cognitive effort. Nor have we designed tools that allow clinicians to control their information environment.[86] Current EHRs do not align with patient's situation and clinician's mental models.[87]

EHR systems often use alerts as a blunt instrument to inform and motivate clinicians, creating significant complaints and alert fatigue.[88,89] Designing EHRs to match work processes is difficult but essential in order to maximize functionality and safety; future work should expand the evidence on effective implementing of decision support systems. Health information technology has disrupted communications, workflow and increased workarounds.[90,91] Maintaining safety requires more than design; it requires participation by the whole institution involved in the EHR implementation. True tests of usability rigorously and independently studied as well as *in vivo* assessments of ongoing performance would necessitate provider and patient input, eventually leading to a common set of core features and functions.

SUMMARY

The problems we face today in EHR use are complex and solutions will not be simple or quick. Solving these problems will require regulatory stability, the development of an acceptable threshold "barrier to entry" into the EHR marketplace, and a supportive national policy. We recommend a focus on these five areas during the next 6-12 months, while we develop a long-term framework for innovation for EHRs.

AMIA has always been in the forefront in the world of EHRs. The EHR 2020 Task Force is the next step in our involvement. We look forward to working with other groups, government agencies and professional organizations to find creative ways to solve EHR problems we face today and to further create a sustainable framework for innovation in EHRs. We look forward to continuing work with policymakers on their critical role in moving our nation toward better use of EHRs to achieve the Triple Aim.[92] AMIA's 2015 annual policy meeting will be devoted entirely to EHRs.[93] Individual AMIA members should also continue to take action to promote EHR improvements through their influence on EHR purchase decisions, criteria in Requests for Proposals, comments on proposed regulations and legislation, continued research on EHR innovation, safety, usability and workflow, and through other means.

We also share the sense of urgency other organizations have expressed about addressing current EHR problems.[94,95,96,97] These problems are soluble and the future for EHRs is bright.

PROVENANCE AND PEER REVIEW

By convening the task force and disseminating this paper, AMIA has further delineated critical issues related to EHR adoption. The AMIA Board of Directors reviewed the paper and endorsed its findings, conclusions and recommendations. The board will continue to encourage other organizations to work collaboratively to continue this important public discourse.

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