ORIGINAL RESEARCH

The Theory and Application of UW eHealth-PHINEX, A Clinical Electronic Health Record–Public Health Information Exchange

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ABSTRACT

Background: Electronic health records (EHRs) hold the promise of improving clinical quality and population health while reducing health care costs. However, it is not clear how these goals can be achieved in practice.

Methods: Clinician-led teams developed EHR data extracts to support chronic disease use cases. EHRs were linked with community-level data to describe disease prevalence and health care quality at the patient, health care system, and community risk factor levels. Software was developed and statistical modeling included multivariate, mixed-model, longitudinal, data mining, and geographic information system (GIS)/spatial regression approaches.

Results: A HIPAA-compliant limited data set was created on 192,201 patients seen in University of Wisconsin Family Medicine clinics throughout Wisconsin in 2007-2009. It was linked to a commercially available database of approximately 6000 variables describing community-level risk factors at the census block group. Areas of increased asthma and diabetes prevalence have been mapped, identified, and compared to economic hardship.

Conclusions: A comprehensive framework has been developed for clinical-public health data exchange to develop new evidence and apply it to clinical practice and health policy. EHR data at the neighborhood level can be used for future population studies and may enhance understanding of community-level patterns of illness and care.

INTRODUCTION

Effective clinical care and public health response greatly depend upon information. With the widespread adoption of electronic health records (EHRs), there is great potential to positively transform these 2 components of the health care system.[1,2] For example, EHRs have reduced clinical errors, improved chronic illness care,[1-3] and improved the completeness, accuracy, and timeliness of case reporting to public health.[4]

A bidirectional data exchange between clinical care and public health could revolutionize how these 2 disciplines interact. Through surveillance and epidemiologic analysis, public health provides situational awareness and improved health outcome prediction modeling for individuals in high-risk populations. Translating merged clinical and public health data into useful information on chronic disease and feeding this new information back to clinicians at the point of care could provide additional decision support.[1] In this way, the high volume and quality of exchanged EHR data could serve as a foundation to create a rapid learning health system, a process to rapidly develop new evidence, learn from it, and apply these findings to medical practice and health policy.[1,5,6]

Population data collected from EHRs has the potential to provide useful information to evaluate condition-specific clinical process metrics and outcomes, facilitate clinical decision support, enhance team-based population care outside the traditional face-to-face clinical encounter, and provide feedback on specific patient populations at the point of care. However, EHR databases must be representative of the populace and its communities if the analytic results are to be useful and meaningful.

The best prevalence estimates for diabetes, asthma, and other chronic conditions in Wisconsin comes from Wisconsin's

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Behavioral Risk Factor Surveillance System (BRFSS)[7] which is part of the nation's largest ongoing annual telephone health survey system tracking health conditions and risk behaviors in residents 18 years old and older. However, the BRFSS is designed only to estimate prevalence at the state level[8] and suffers from the biases of self-report and low response rate.[9] Based on increasing implementation of EHRs, it may be more efficient and less costly to study chronic disease from a public health viewpoint through de-identified clinical data rather than telephone survey systems and other currently available survey methods.

Constructing, reviewing, and reporting on summary quality measures is a very important and a necessary first step to improve health care delivery systems. However, it is not sufficient because the aggregated measures by themselves provide limited insight into what contributes to performance variation and what solutions or interventions might be proposed. Simply reducing clinical practice quality variation is insufficient to substantially improve the health of individuals and populations.

The multiple determinants that contribute to disease, risk, disparity, and performance of the health care system can be more completely described through an ecologic health systems model. This model reflects individual biologic factors and behaviors, clinical care elements, and social, family, environment, and community characteristics.[10-12] Furthermore, a multilevel, systems approach that examines diseases within their biological, psycho-socioeconomic, environmental, and community contexts is likely to provide a better understanding of disease disparities and clinical quality outcomes.

There has been broad bipartisan support for making universal EHR adoption a national priority. Beginning with a 2004 presidential directive, the Office of the National Coordinator for Health Information Technology (ONC) was established and charged with developing a nationwide health information network to improve health care quality, make health care safer and more efficient while also improving population health and reducing cost.[1] Building on ONC's activities, the 2009 Health Information Technology for Economic and Clinical Health (HITECH) Act was established, making substantial investments to stimulate widespread EHR adoption. Starting in 2011, HITECH offers eligible health care providers financial incentives for demonstrating meaningful use of EHRs. To receive incentives, providers must use certified EHR systems to electronically capture health information in a coded format, use it to track key clinical conditions, coordinate care, and initiate the reporting of clinical quality measures (CQMs) and public health information.[13,14]

We describe the University of Wisconsin Electronic Health Record – Public Health Information Exchange (UW eHealth-PHINEX) program which is designed to statistically represent the ecologic health systems model. In addition, this paper will describe the overall demographics of this clinic population and compare it to the broader Dane County and statewide populations. It is planned to serve as a resource for physicians and allied health professions for training, research, continuous health care quality and population health improvement, public health system improvement, and surveillance.

METHODS

Setting

This research was conducted at the University of Wisconsin-Madison School of Medicine and Public Health and the Wisconsin Division of Public Health. In January 2010, the Healthcare Information and Management Systems Society (HIMSS) recognized the University of Wisconsin Hospital and Clinics with the HIMSS Analytics Stage 7 Award for delivering care without the use of paper charts, sharing patient information securely with other providers of care, and using their vast database of clinical information to improve patient safety and outcomes.[15] Stage 7 indicates the most advanced use of EHRs. It is the pinnacle of an environment where paper charts are no longer used to deliver patient care.

The University of Wisconsin Department of Family Medicine (DFM)[16] operates 25 clinics throughout the state with 187 faculty, 100 residents, and nearly 700 employees. Together these organizations use the Epic EHR[17] to deliver care to nearly 200,000 patients who are seen in the DFM clinics.

The Division of Public Health (DPH) is responsible for providing public health services to the people of Wisconsin. The Office of Health Informatics operates the Public Health Information Network (PHIN), which includes a secure web portal that offers advanced statistical analysis, visualization, and reporting (AVR) services for surveillance and epidemiologic investigation.[18]

Project Design, Participants, and Procedures

The project was designed to transform current health information systems to an improved state that could then fully encompass the ecologic health systems model. It used the collaborative requirements development methodology[19] to develop information technology (IT) requirements and specifications. The Information Technology—Enterprise Performance Life Cycle (EPLC) was used as a guide for project management. The EPLC framework consisted of 10 life-cycle phases: initiation (identify business need), concept (identify high level requirements), planning (full project management plan), detailed requirements (what it must do), design, development (coding), testing, implementation, operations, and management.[19]

Focus groups developed system needs by first looking at how work is currently done (business process analysis), how the work could be done better (business process redesign), and how information systems could support the new processes (requirements development).[20] These teams developed requirements and specifications for data security, access, and analysis. Working from these requirements, clinician-led teams next developed detailed Epic data extract and analysis criteria for asthma and diabetes "use cases" (a use case defines the information needs for a health outcome or risk factor under investigation). Commercially available databases were identified to provide community-level information. Information technologists then developed the PHIN AVR Web Portal data systems based on these criteria. Patient data was exchanged if charges were generated during a 3-year period for any patient that had a clinical encounter in any of the 25 UW DFM clinics using the UW Health Link Epic EHR platform.

Mapping

Asthma and diabetes prevalence variation was mapped and identified. EHRs were geocoded by matching the patient address to its latitude-longitude coordinates. Once the latitude-longitude was obtained, the patient record was matched to the census block group (600- to 1500-person neighborhoods) and census tract (2500 and 8000 person county subdivision) where it was located. Ancillary to the geographic codes, the ICD-9 codes (473.xx for asthma and 250.xx for diabetes) were carried forward from the EHR to the geocoded points.

Using a geographic information system (GIS), the individual points were aggregated to the census tract, providing a count by census tract of the overall total number of patients as well as the total number of patients with either asthma or diabetes in order to determine the disease prevalence. Once the aggregation was complete, these data could be graphically represented to illustrate the prevalence of both asthma and diabetes within each census tract. The prevalence was reported in terms of the percent of the population with the specific condition being evaluated. The prevalence values were then associated with a 5-class grey shading scheme that allowed a visual depiction of the distribution of both asthma and diabetes prevalence in a map of Dane County, Wisconsin.

The social and economic conditions by census tract in the Dane County area were described using the economic hardship index.[21,22] The index is scored by combining 6 indicators: crowded housing (percent of housing units with more than 1 person per room), poverty (percent of households living below the federal poverty level), unemployment (percent of persons over the age of 16 years that are unemployed), education (percent of persons over the age of 25 years without a high school education), dependency (percent of population that is under age 18 or over age 64 years), and income level (median per capita). Data for these indicators were obtained from the 2010 US Census. Scores on the index can range from 1 to 100, with a higher index number representing a greater degree of economic hardship.

RESULTS

Logic Model

Figure 1 displays the logic model for the UW eHealth-PHINEX project. Funding, systems, staffing, data, and organizations were the inputs to carry out project activities. Implementation activities included developing specifications, performing disease prevalence and clinical quality statistical modeling, exchanging data, and creating the secure web portal. Some of the challenges included obtaining a data use agreement between UW and DPH, finding and hiring a skilled Epic programmer, and procuring Human Subjects Institutional Review Board approval.

Five focus groups were held. Three groups were with public health epidemiologists and data stewards (ie, public health data security, access, analytics) and 2 groups were with health care administrators and clinicians (ie, clinical data security and access; clinical-public health data integration [which also included public health epidemiologists and medical officers]). A physician, epidemiologist, and database analyst team met to develop the detailed EHR data extract specifications for asthma and diabetes use cases. Teams subsequently met biweekly to develop detailed disease analysis and modeling reports.

Statistical specifications went beyond current practices of simple descriptive statistics and included multivariate analyses, mixed-model multivariate analyses, data mining, and GIS/spatial regression.[23-26]

The principal project outputs are detailed demographic, clinic, and community-specific reports that identify the multiple determinants of disease prevalence, disparity, and health care quality. Over the short-term, we anticipate this approach will lead to improved insight into the determinants for each of these factors. This, in turn, can then serve as the foundation for multilevel intervention trials with the potential for reduction in disparity and disease risk factors, and improved clinical outcomes. The long-term goal is the achievement of the Institute for Healthcare Improvement's Triple Aim: improving population health, improving the patient experience including health care quality, and reducing per capita cost of care.[27]

Conceptual Model

Figure 2 provides a conceptual overview of the information systems environment and consists of a 3-step process to improve health care quality and population health: finding patterns in the data to gain insight, running comparative effectiveness trials to discover new methods of improving care and effective policies, and promoting the new, more effective method to be the standard of care while repeating the discovery process for

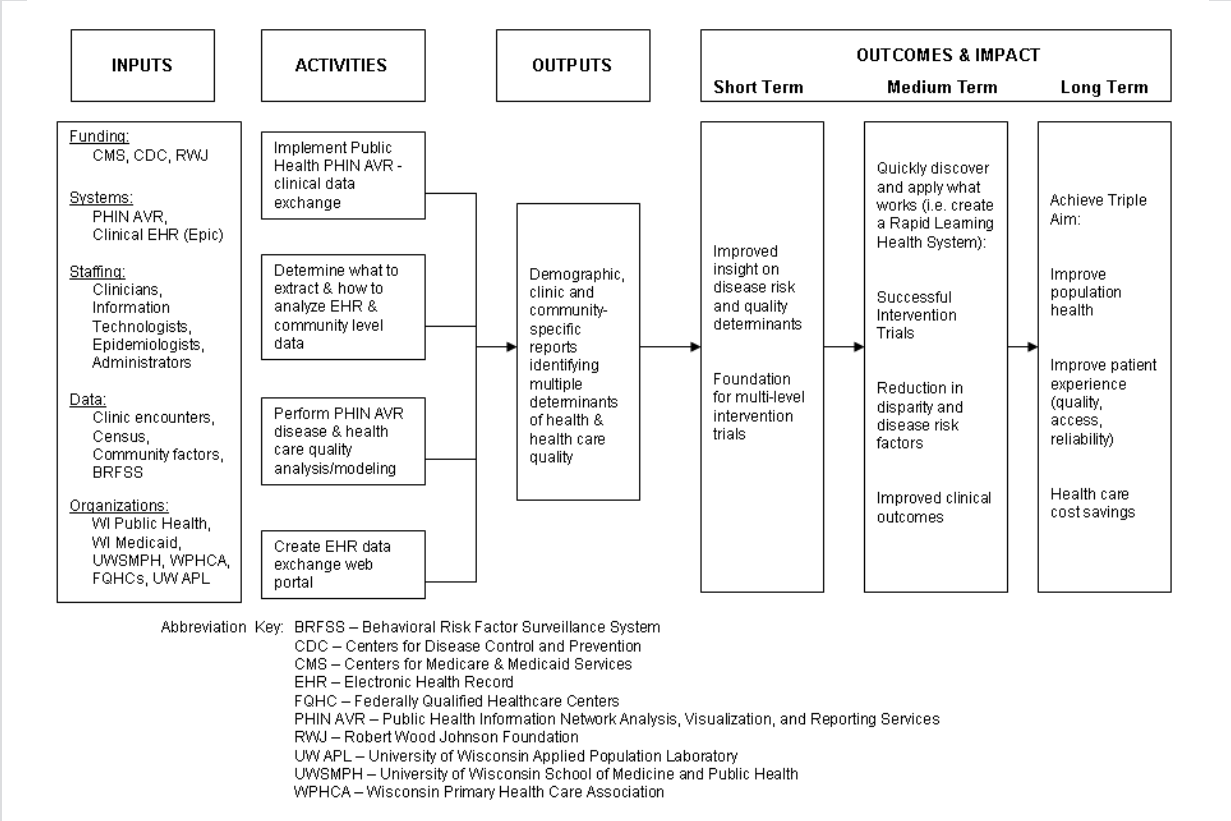

Figure 1. The logic model for the UW eHealth-PHINEX project.

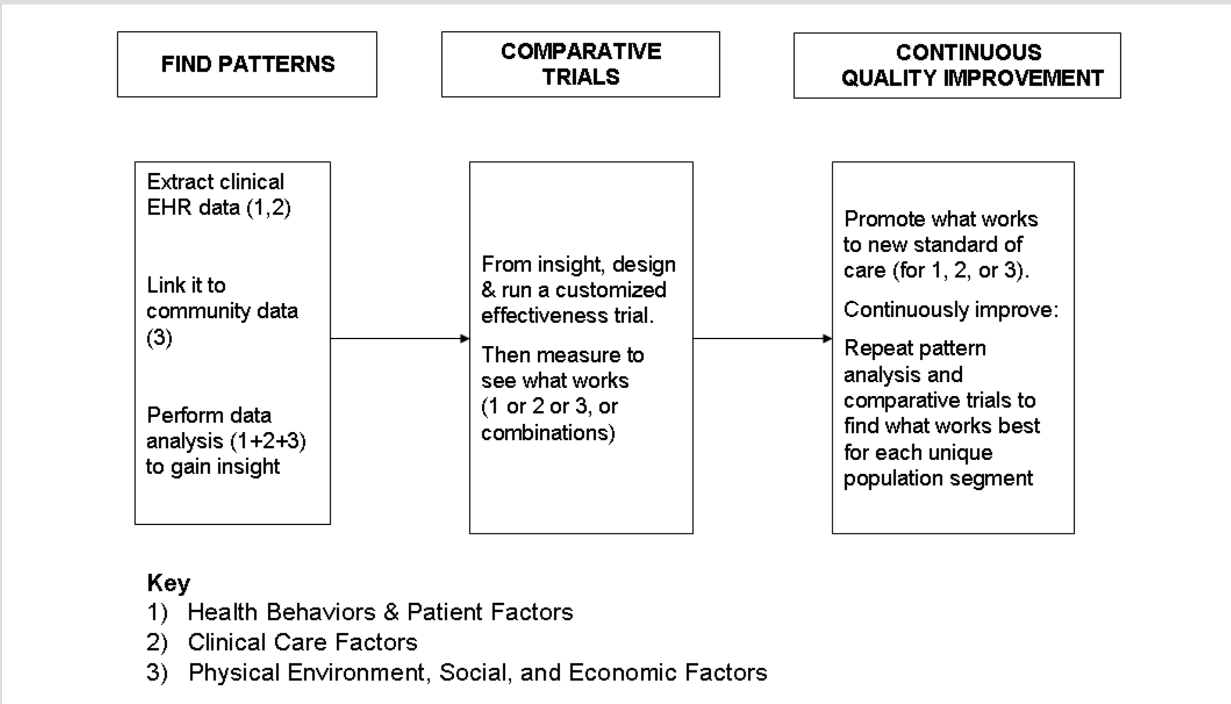

Figure 2. A conceptual overview of the information systems environment.

Outcomes =	Health Behaviors & Patient Factors +	Clinical Care Factors +	Physical Environment, Social, and Economic Factors
Asthma Diabetes Heart Disease Arthritis Immunizations Obesity Hypertension Smoking Alcohol Meaningful Use & Pay for Performance Quality Measures A1c level HDL/LDL Hospitalizations Health Care - Process factors (e.g, time to follow-up)	Health Behaviors Age Gender Race/ethnicity Occupation Industry/employment Co-morbidities Medications Language Literacy Insurance Census Block Group	Clinician: Age Gender Certifications Graduation date Years of practice Clinic: Location Capabilities Processes	Census Block Group: Poverty / Economic Hardship Education level Businesses Consumer demographics Restaurant mix Retail food environment index Fast food sales & consumption Fresh fruit & vegetable sales & consumption Urban - Rural Built environment: Traffic Recreation / parks Safety / crime Environmental quality (air, water) Public Health Programs
Electronic Health Record Data			Census, Community Data and Public Health Information Systems

Figure 3. Overview of the EHR extract linked to the community risk factor data set.

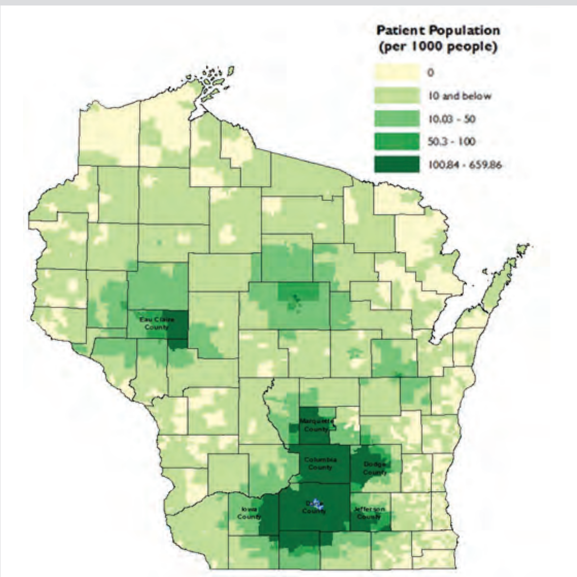

Figure 4. The geographic distribution of 192,201 patients seen at 25 UW Department of Family Medicine clinics by census block group (2007-2009).

population segments that did not benefit from the intervention. This data exchange project is currently at the first step of finding patterns.

The ecologic health systems model, like the county health rankings model,[28] recognizes that health behaviors, clinical care, social and economic factors, and the physical environment may determine if someone stays healthy or not. Examples include the following: (1) health behaviors–activities to maintain health such as smoking avoidance, moderate alcohol consumption, regular exercise, and appropriate body weight for height; (2) clinical care–quality metrics that define if a health care system is meeting a standard of care (eg, HbA1c <7 for patients with diabetes). Evaluation of the quality metric performance varies by patient and community-level risk factors; and (3) social and economic factors, and physical environment–determining if individuals have an adequate income to afford health-promoting foods and evaluating if an individual's neighborhood supports safe exercise outdoors, provides access to fresh fruits and vegetables, and offers a wide variety of restaurants rather than only fast food.

From the data exchange, one can begin to find patterns in these factors. First, the HIPAA-limited EHR data set was extracted (eg, diagnoses, lab results, demographics, vital signs, body mass index, and smoking history). The data set was linked to community-level data [eg, economic hardship, employment, fresh fruit and vegetable consumption] at the census block group or census tract level.

Disease prevalence and health care quality was assessed by various statistical approaches, including multivariate analyses and data mining. The areas of health behaviors, clinical care, and community factors were modeled to gain insight on what variables predict health, disease, and health care quality, which would then contribute to designing comparative-effectiveness trials. The success of interventions could in part be measured through information contained within the EHR. Furthermore, characteristics of individuals who had success could be compared to individuals who did not. The advantage of using the EHR is that the results may be more generalizable to a clinic population, the trial may suffer less subject dropout, and the patient burden of clinical trial visits may be reduced. Clinicians and investigators may benefit by learning which interventions are effective or not.

Community Level Data (Social, Economic, and Environmental Factors)

The Esri Business Analyst (BA) Premium product[29] has approximately 6000 variables at the census block group level, on community demographics, socioeconomic segmentation, consumer spending, business locations and type, street data, and market potential.[29] Census block groups are the smallest geographical unit for which the US Census Bureau publishes sample data.

BA data was acquired and linked to the EHR at the census block group.

Clinical EHR Data Model

There were 111 variables extracted from the Epic Clarity database, including encounter and problem list diagnoses, social history/patient demographics, laboratory test orders and results, procedures, vital signs, and medications. This extract included data from patients seen during the years 2007-2009 in 25 UW DFM clinics. This encompasses 192,201 patients, 2.54 million encounters, 3.1 million diagnoses, and 1.54 million laboratory results. These data complied with the HIPAA privacy rule for limited data sets. In this limited data set, all protected health information was removed except date of encounter, birth month and year, ZIP code, and census block group of the patient's address. Random accession numbers were created for patient, primary care provider, and clinic. This allowed for analysis on these factors while keeping patient, provider, and clinic identities anonymous. Results can then be fed back to the UW DFM to decode identities internally and reveal individual patient, provider, and clinic quality performance characteristics and inform practice.

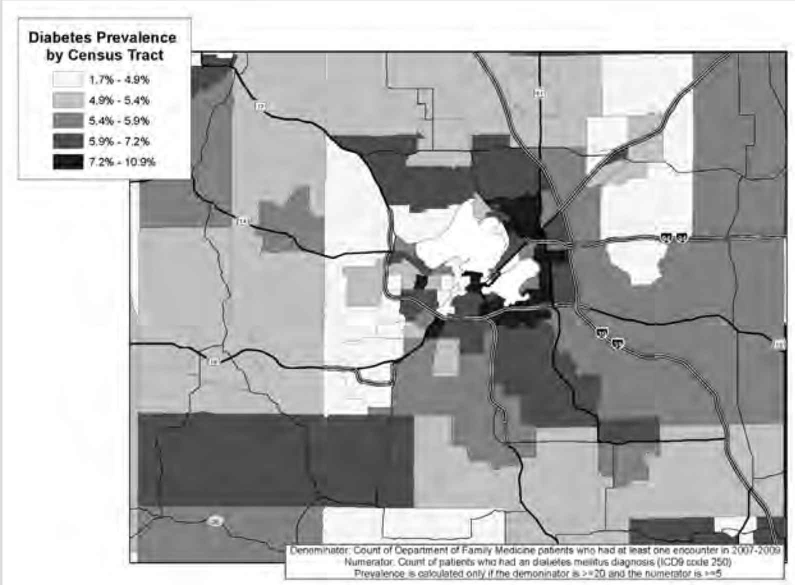

Figure 5. Diabetes Prevalence by Census Tract, Dane County (2007-2009).

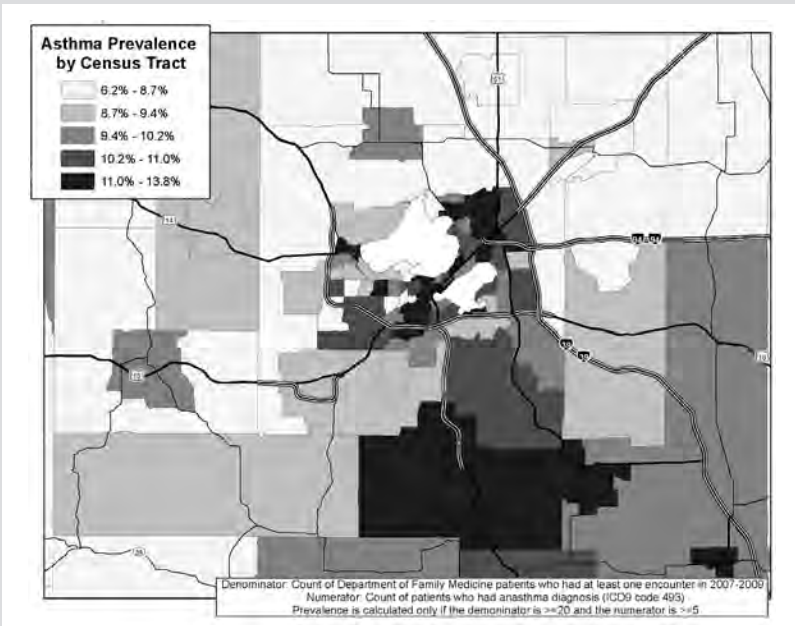

Figure 6. Asthma Prevalence by Census Tract, Dane County (2007-2009).

Ecologic Health Systems Modeling

Figure 3 provides an overview of the EHR extract linked to the community risk factor data set. Outcomes (asthma and diabetes prevalence, meaningful use quality measures, etc) can be modeled as a function of health behaviors and patient factors (smoking, age, gender, race/ethnicity, comorbidities), clinical care factors, and social, economic and physical environment community factors (eg, poverty, economic hardship, built environment, fresh fruit and vegetable consumption, etc).

Population Demographics

Figure 4 shows the geographic distribution of patients seen at UW DFM clinics. While most patients cluster in and around Dane County and surrounding counties (Sauk, Columbia, Dodge, Jefferson, Iowa, Rock, Green, and Marquette), there was still a widely dispersed sampling of patients throughout the rest of the state because of patients seen at the Eau Claire, Augusta, Wausau, and Appleton DFM clinics.

The DFM clinic sample contained 40,320 children and 151,881 adults. A statewide comparison of census and UW eHealth-PHINEX demographics showed that the UW eHealth-PHINEX population is fairly representative of the Wisconsin

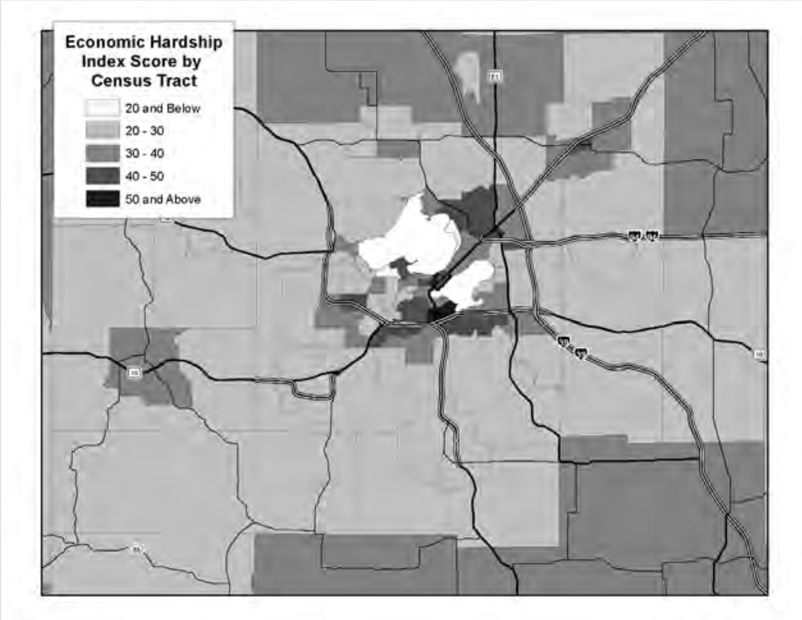

Figure 7. Economic Hardship Index by Census Tract (2010).

statewide census population (Table 1) with the following exception. There was a smaller percentage of adults 65 years or older in the UW eHealth-PHINEX population (9.34%) compared to the state population (13.31%).

Because the majority of the DFM clinic patient population resides in Dane County, we also made a demographic comparison to this area (Table 2). Within Dane County, the UW eHealth-PHINEX population slightly over-represents non-Hispanic Blacks (5.70% vs 4.95%) but has a similar representation of Hispanics (4.79% vs 4.99%).

The map of diabetes prevalence of the UW eHealth-PHINEX population in Dane County reveals considerable variation in diabetes prevalence. It ranges from 1.7%-4.9% (lowest quintile) to 7.2%-10.9% (highest quintile) (Figure 5). The map shows neighborhoods in the northeast, east and the southeast have the highest diabetes prevalence (Figure 5). The map of asthma prevalence also indicates a substantial range of prevalence (6.2%-8.7% [lowest quintile] to 11.0%-13.8% [highest quintile]) (Figure 6). It shows neighborhoods in the northeast and the south have the highest asthma prevalence.

Use Case Studies: Asthma, Diabetes, Economic Hardship Index

Areas of increased asthma and diabetes prevalence have been mapped and identified in Dane County (Figures 5 and 6) and compared to the economic hardship index (Figure 7). Economic hardship appears to correlate with diabetes risk and to a lesser extent with asthma. Formal testing of this association is planned. Data mining is under way to examine the multiple predictors of asthma. Multivariate modeling is being performed to describe asthma and diabetes disease prevalence, and the determinants of pediatric obesity. These results are being compared to traditional public health data systems, such as the BRFSS telephone survey. Finally, clinical quality measures also are being studied for these conditions. Using predictive analytics, poor HbA1c control is being examined by patient demographic and community-level risk factors. Detailed reports on all of these findings are being prepared and will be published at a later date.

DISCUSSION

The UW eHealth-PHINEX project is an information system platform to statistically represent the ecologic health systems model. The study demonstrates that data from a network of family medicine clinics from a multispecialty practice within an academic center is able to reasonably approximate the populations of its surrounding county and state. EHR databases also may offer better availability of data by subpopulations such as children, elderly, certain racial and ethnic groups, disabled persons, and/or a particular gender compared to traditional survey data. As clinical systems become more accountable by producing quality indicators for meaningful use and pay-for-performance, combining EHR and census block group data becomes fundamental to creating accurate comparisons and understanding the multiple predictors of clinical quality and public health system performance. It then provides the basis for designing and testing a spectrum of potentially effective interventions at the patient, health behavior, clinical care, and community levels (social, economic, and physical environment).[29-31] These insights can then be used to develop tailored interventions optimized for specific segments of our patient populations and their communities. In this way, more personalized care can be offered to increase the likelihood of individual response and increase the probability that these efforts will improve their health. The UW eHealth-PHINEX is a roadmap for this approach.

The creation of quality metrics is a necessary first step for improving any system, but it is only the beginning. Simple, aggregate health care quality measures have limited utility.[32] Instead it also is necessary to understand the multiple determinants that drive variations in quality (such as health behaviors, poverty, or the physical environment). UW eHealth-PHINEX provides a platform to accomplish this task. In the future, it will be possible to feed back the merged clinical and community data and use this information to inform individual patient treatment and engagement at the point of care. Local public health jurisdictions could collaborate with clinical care systems on the community-level interventions and monitor clinical outcomes. New standards of community-level care could be promoted and populations at risk identified for further interventions.

It is estimated that clinical care accounts for only 20% of health outcomes, while 30% is related to health behaviors, another 40% is attributable to social and economic factors, and the remaining 10% is related to the physical environment.[28-33] Thus, if comparative effectiveness research's full potential for improving the population's health is to be realized, such comparisons must go beyond those differences found between 2 medications or devices. These comparisons must be made along with behavioral interventions, either alone or in conjunction with other approaches.[34,35] By modeling the interplay of the multiple determinants of disease, the UW eHeath-PHINEX platform can pinpoint health disparity and related environmental features at the local level to suggest interventions and areas to focus limited public health resources.

Table 1. Wisconsin Statewide Comparison of Census and UW eHealth-PHINEX Clinic Demographics (2007-2009).

	Wisconsin Census Data 2007-2009[a]		Wisconsin UW eHealth-PHINEX Patients 2007-2009	
	N	Percent (95% CI)	N[b]	Percent (95% CI)
Overall	5,627,985		192,201	
Sex				
Male	2,795,161	49.67 (49.61 – 49.72)	88,485	46.04 (45.74 – 46.34)
Female	2,832,824	50.33 (50.28 – 50.39)	103,710	53.96 (53.63 – 54.29)
Age Group				
0-4	361,847	6.43 (6.41 – 6.45)	12,914	6.72 (6.60 – 6.83)
5-11	496,694	8.83 (8.80 – 8.85)	12,898	6.71 (6.59 – 6.83)
12-17	458,426	8.15 (8.12 – 8.17)	14,508	7.55 (7.43 – 7.67)
18-34	1,284,712	22.83 (22.79 – 22.87)	51,647	26.87 (26.64 – 27.10)
35-64	2,277,326	40.46 (40.41 – 40.52)	82,275	42.81 (42.51 – 43.10)
65+	748,981	13.31 (13.28 – 13.34)	17,959	9.34 (9.21 – 9.48)
Race/Ethnicity				
White, Non-Hispanic	4,809,406	85.46 (85.38 – 85.53)	161,042	87.99 (87.56 – 88.42)
Black, Non-Hispanic	352,101	6.26 (6.24 – 6.28)	7,456	4.07 (3.98 – 4.16)
Other, Non-Hispanic	178,549	3.17 (3.16 – 3.19)	6,672	3.65 (3.56 – 3.74)
Hispanic	287,930	5.12 (5.10 – 5.13)	7,858	4.29 (4.20 – 4.38)

[a]Average of 3 years of estimates (2007-2009), based on the 2000 US Census
[b]Due to missing data within each variable, stratified counts may not sum to overall N

Table 2. Dane County, Wisconsin, Comparison of Census and UW eHealth-PHINEX Clinic Demographics (2007-2009).

	Wisconsin Census Data 2007-2009[a]		Wisconsin UW eHealth-PHINEX Patients 2007-2009	
	N	Percent (95% CI)	N[b]	Percent (95% CI)
Overall	483,639		117,486	
Sex				
Male	240,048	49.63 (49.44 – 49.83)	54,699	46.56 (46.17 – 46.95)
Female	243,591	50.37 (50.17 – 50.57)	62,786	53.44 (53.02 – 53.86)
Age Group				
0-4	30,567	6.32 (6.25 – 6.39)	8,279	7.05 (6.90 – 7.20)
5-11	38,313	7.92 (7.84 – 8.00)	8,248	7.02 (6.87 – 7.17)
12-17	32,567	6.73 (6.66 – 6.81)	8,814	7.50 (7.35 – 7.66)
18-34	148,049	30.61 (30.46 – 30.77)	31,238	26.59 (26.29 – 26.88)
35-64	187,096	38.69 (38.51 – 38.86)	51,443	43.79 (43.41 – 44.16)
65+	47,047	9.73 (9.64 – 9.82)	9,464	8.06 (7.89 – 8.22)
Race/Ethnicity				
White,Non-Hispanic	410,496	84.88 (84.62 – 85.14)	97,097	85.60 (85.06 – 86.14)
Black, Non-Hispanic	23,927	4.95 (4.88 – 5.01)	6,467	5.70 (5.56 – 5.84)
Other, Non-Hispanic	25,088	5.19 (5.12 – 5.25)	4,437	3.91 (3.79 – 4.03)
Hispanic	24,127	4.99 (4.93 – 5.05)	5,434	4.79 (4.66 – 4.92)

[a]Average of 3 years of estimates (2007-2009), based on the 2000 US Census
[b]Due to missing data within each variable, stratified counts may not sum to overall N

An EHR-public health data exchange such as the one described in this study can provide superior public health surveillance information on chronic conditions such as asthma and diabetes. When these data are used to map patterns of disease, they can identify neighborhoods with high prevalence of chronic disease such as diabetes (Figure 5) and asthma (Figure 6) and compare these risks to community factors such as increased economic hardship (Figure 7). This type of exchange has the potential to improve surveillance, and better inform local public health community health improvement plans,[36,37] accreditation and quality improvement,[38] and nonprofit hospital community health needs assessments.[37] For example, the county health rankings is an invaluable methodology to support local public health community assessments and evaluations, and while it is extremely important to compare disease prevalence and disparity among local jurisdictions by ranking them, it is equally if not more important to understand disparities within the local jurisdiction itself. Consider Dane County, a community with a high health ranking. It is 11th out of 72 Wisconsin counties,[38] yet the UW eHealth-PHINEX was able to pinpoint substantial variation in asthma and diabetes burden, along with economic hardship within the county itself. These within-health jurisdiction analyses are vitally important to a comprehensive understanding of population health risks and the efficient targeting of limited public health resources.

The Institute of Medicine recently issued its report *Primary Care and Public Health: Exploring Integration to Improve Population Health*[39] and it called for greater integration between the 2 disciplines. This report suggests that a collaboration between primary care and public health will result in achievement of each organization's individual goals and have an overall greater impact on population health than each organization working alone. Each group brings unique knowledge, resources, and skills to analyze clinical data in ways that can promote the health of individual patients and communities.[39] The UW eHealth-PHINEX program has anticipated these IOM recommendations by creating a robust clinical data exchange platform with the potential to improve health care quality and the health of Wisconsin's citizens and communities. Future plans include expansion of the dataset to incorporate data from UW Pediatric and Internal Medicine primary care clinics. This work has implications beyond our local exchange and could serve as a model for future statewide and national EHR-public health data sharing.

Limitations

This project is limited to a component, UW DFM, of 1 integrated health care system; within that health system, patients may receive care in other health systems where data may not be readily accessible for exchange. Furthermore, patients are not randomly sampled from all areas of Wisconsin. These patients come to the UW clinic for care and most have insurance. Therefore, our data may underestimate the magnitude of disparities in asthma and diabetes prevalence by racial and ethnic categories that are available in greater numbers in larger Wisconsin cities. Prevalence estimation and quality predictors could be substantially improved if all of Wisconsin's EHR data were similarly combined and analyzed using the emerging statewide EHR data exchange, the Wisconsin Statewide Health Information Network (WISHIN).[40] WISHIN support of the data exchange functions demonstrated here should be considered as it evolves and matures.[5]

CONCLUSIONS

A comprehensive framework has been developed and demonstrated for clinical-public health data exchange. It supports a rapid learning health system to better appreciate the multiple determinants of disease disparity and health care quality, and can serve as an information platform for continuous quality improvement of clinical care and population health. Health information technology and, more specifically, EHR data exchange, have the potential to provide the critical information we need to better understand both our individual patients and populations we serve.

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