Patterns and Correlates of Public Health Informatics Capacity Among Local Health Departments: An Empirical Typology

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Abstract

Objective: Little is known about the nationwide patterns in the use of public health informatics systems by local health departments (LHDs) and whether LHDs tend to possess informatics capacity across a broad range of information functionalities or for a narrower range. This study examined patterns and correlates of the presence of public health informatics functionalities within LHDs through the creation of a typology of LHD informatics capacities.

Methods: Data were available for 459 LHDs from the 2013 National Association of County and City Health Officials Profile survey. An empirical typology was created through cluster analysis of six public health informatics functionalities: immunization registry, electronic disease registry, electronic lab reporting, electronic health records, health information exchange, and electronic syndromic surveillance system. Three-categories of usage emerged (Low, Mid, High). LHD financial, workforce, organization, governance, and leadership characteristics, and types of services provided were explored across categories.

Results: Low-informatics capacity LHDs had lower levels of use of each informatics functionality than high-informatics capacity LHDs. Mid-informatics capacity LHDs had usage levels equivalent to high-capacity LHDs for the three most common functionalities and equivalent to low-capacity LHDs for the three least common functionalities. Informatics capacity was positively associated with service provision, especially for population-focused services.

Conclusion: Informatics capacity is clustered within LHDs. Increasing LHD informatics capacity may require LHDs with low levels of informatics capacity to expand capacity across a range of functionalities, taking into account their narrower service portfolio. LHDs with mid-level informatics capacity may need specialized support in enhancing capacity for less common technologies.

Keywords: Public health informatics, local health department, information systems, typology.

Abbreviations: Local health department (LHD), Information systems (IS), Information technology (IT)

Introduction

Public health informatics and information systems have long been cited as a way to strengthen the work of public health departments [1,2]. A strong body of evidence exists that shows positive benefits to public health in using a wide range of informatics-based systems [3-7]. In addition, adoption of health information technologies by hospitals and providers in the clinical sector [8,9] may present an even greater opportunity for public health departments to leverage informatics to improve population health [10].

A large proportion of the work to assure, assess, and develop policies to promote population health is undertaken by local health departments (LHDs) [11]. LHDs can use information technology to enhance capacity for data collection, examination, and dissemination [12]. The science of systematically applying information technology and information systems to public health practice, research, and learning is known as public health informatics [12,13].

Evidence suggests that, relative to other industries, LHDs may be lagging in use of informatics and adoption of information systems [6,14,15]. Some of the most recent large scale evidence on overall levels of informatics capacity among LHDs comes from surveys conducted in 2008 and late 2009. Vest et al. determined that while overall use of information systems (IS) and information technology (IT) by LHDs was low in 2008, there is clear evidence that LHD structure, governance, finance, and types of service provided characteristics were associated with IS and IT usage [14]. This provides empirical evidence supporting the conceptual linkage between LHD characteristics, public health service provision, and health IS/IT usage. A second survey focused on LHD informatics reiterated the link between LHD jurisdiction size and use of certain informatics functionalities [16]. More recent evidence suggests that, as in the rest of the health care sector [9,17], health IS utilization by LHDs, and in particular electronic health records, has changed substantially since 2010 [18].

Accompanying this increased system-wide capacity for capturing, storing, and transmitting data electronically is a call for LHDs to become informatics-savvy [19]. Yet currently, very little is known about which informatics systems are actually being used by LHDs [12]. Even less is known about interrelationships between systems, whether informatics capacities are symbiotic, where use of one system can facilitate or enhance the use of other system(s), or whether informatics systems operate on a zero-sum basis and tend to crowd out one another. Building informatics capacity may mean that LHDs will need to coordinate informatics needs and resources across programs and services, implement new or improved IS/IT systems, or enhance their informatics workforce [19,20]. This means that, in addition to exploring the presence or absence of individual informatics functionalities, it may be beneficial to measure and explore broad-based measures of LHD informatics capacity.

The purpose of this study was to test for patterns in the presence of public health informatics functionalities within LHD through the creation of an empirical classification of LHD informatics capacities. This empirical classification was then used to explore correlates of low-, mid-, and high-informatics capacity LHDs.

Methods

Conceptual Model

Several primary factors were hypothesized to motivate LHDs to establish high capacity in public health informatics—1) LHD financial and workforce characteristics [21]; 2) LHD organization, governance, and leadership [22,23]; and[REMOVED HYPERLINK FIELD] 3) the types of services provided by an LHD [24-27]. Each of these three categories have been shown to correlate with LHD adoption and use of electronic health records [18], an important informatics functionality.

Data

Data from the 2013 National Association of County & City Health Officials (NACCHO) Profile survey were used. The Profile survey methodology is described in detail elsewhere [28]. The Profile survey is a census of LHDs conducted approximately every three years. All LHDs receive a core questionnaire and a stratified random sample of LHDs are also assigned one of two modules to complete. Informatics questions are included in one of the modules, so only a subsample of LHDs report data on this topic. In 2013, the module included questions about informatics usage provided data for 505 LHDs (79% overall response rate).

In addition to informatics data, the NACCHO Profile survey also contains information on LHD financial, workforce, organization, governance, and leadership characteristics and types of services provided.

Measures

Primary Measure of Interest

The primary measure of interest was a LHD's informatics capacity. This measure was operationalized through the creation of an empirically-based typology.

NACCHO Profile survey data on LHD awareness, consideration, and implementation of five informatics functionalities: electronic health records, health information exchange, immunization registry, and electronic disease registry. For each system, survey response options included: no activity, have investigated, planning to implement, have implemented. In addition, use of electronic syndromic surveillance was assessed through a dichotomous measure (yes/no).

Hierarchical cluster analysis methods were used to categorize LHDs according to public health informatics capacity. The Ward method was used to group LHDs into clusters, with similarities assessed using the squared Euclidean distance method [29]. A three-cluster measure was determined to provide the optimal combination of data fit and parsimony. This approach is consistent with previous typology developments within LHDs [30].

To test the reliability of this novel typology of public health informatics capacity, the data were randomly partitioned into two mutually exclusive 'training' and 'validation' datasets. Empirical clusters were re-calculated for each of the two datasets. The resulting samples were then compared along LHD financial, workforce, organization, leadership, and governance characteristics, and types of services provided, as shown in the Appendix Table A1. This method has been used in other public health informatics research as a way of testing the sensitivity of model calculations to the specific data included in the analytic sample [31]. Due to changes in

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the NACCHO Profile survey questionnaire, it was not possible to use data from other survey years to perform reliability testing. Future Profile surveys containing data on these six informatics functionalities may enable these comparisons in the future.

Predictors of Interest

Several variables were used within the three broad categories hypothesized to motivate LHDs to establish high capacities for public health informatics. All predictors of interest were obtained from the 2013 NACCHO Profile survey.

LHD finances were assessed through per capita expenditures in five categories: Total, Local sources, State and federal sources, Medicare/Medicaid sources, and Other clinical sources. All expenditure categories were divided by the LHD's population served. LHD workforce was assessed through two measures: total full-time equivalent (FTE) positions per 10,000 population, and whether the LHD employed informatics personnel (termed "information systems" personnel on the survey instrument).

The organization and governance of LHDs was assessed through five measures: 1) whether the LHD is governed by a local board of health (LBOH); 2) whether the department is freestanding or part of a larger health and human services (HHS) agency; 3) whether the LHD is a single-county jurisdiction or any other type (e.g., city, city-county, multi-county, other complex type); 4) whether the LHD has the statutory authority to set or impose fees for public health; and 5) whether the LHD had a state, local, or shared governance structure. In addition to these measures, LHDs were analyzed by state to assess intra-state variation in informatics capacity. Due to NACCHO Profile restrictions on identifying respondents and to small sample sizes within each state, state-specific results are not presented individually.

LHD leadership was assessed through a measure of whether the department's executive director has a clinical background (defined as MD, DO, RN, MSN, BSN, LPN, or LVN [23]). The clinical versus non-clinical background of an executive director has been shown to correlate with department strategy and performance [23].

Finally, the types of services provided by an LHD were assessed through measures of LHD direct provision of an expansive list of public health services. Previous research has revealed that breadth of LHD service provision is positively associated with likelihood of EMR usage [18]. This study therefore uses broad range of services, relying on a set of 42 services categorized by Bekemeier et al. as being either individual- or population-focused, and as basic, expanded, or specialized [32].

Analysis

Analyses focused on LHDs with data on informatics use for 2013. From the original module sample of n=505, a total of 46 LHDs were excluded due to missing data for at least one informatics functionality; the final sample size was 459 LHDs. Analysis of LHDs with missing data suggests that these 46 LHDs did not differ significantly from the 459 LHDs with complete data, with the exception that LHDs included in the analytic sample were more likely to be single-county jurisdictions than those excluded.

Univariate and bivariate analyses were conducted to examine relationships between the primary outcome of interest (classification on LHD public health informatics typology) versus predictors of interest. Sample weights were used in univariate and bivariate analyses to account for survey

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design and non-response [33]. Chi-square and ANOVA tests were used to examine significant associations. Pair-wise comparisons of means were used to test for significant differences in predictor variables across the typology's three categories, with significance levels adjusted using the Tukey method [34].

Finally, sensitivity of results to outcome coding decisions, survey weights, and other alternative model specifications were explored. Overall findings were not sensitive to variable coding or model specification (results available from author upon request). All analyses were performed using Stata version 13.1 [35]. Institutional Review Board approval was not required as the research did not involve human subjects or individually-identifiable data.

Results

A total of 459 LHDs were included in this study. Characteristics and univariate statistics on the sample are summarized in table 1.

Table 1: Analytic Sample of Local Health Departments (n=459)

LHD Characteristic	Percent or Mean (SD)
Population Served:	
< 50,000	47.7%
50,000 – 499,999	39.4%
≥ 500,000	12.9%
Per Capita Expenditures ($):	
Total	47.85 (3.60)
Local Sources	11.75 (0.69)
State and Federal Sources	19.43 (2.20)
Medicare/Medicaid Sources	9.60 (2.40)
Other Clinical Sources	2.52 (0.59)
Workforce:	
Total FTEs per 10,000	5.5 (0.8)
Employs any Information Systems Personnel	37.4%
Organization, Governance & Leadership:	
Has Local Board of Health	70.0%
Freestanding, not part of HHS Agency	27.1%
Single county jurisdiction	75.4%
LHD has authority to set/impose fees	71.6%
Executive Director has Clinical Background	46.2%
Governance type:	
State	19.6%
Local	72.3%
Shared	8.1%
Public Health Services:	
Number services provided by LHD	18.7 (1.0)

The empirical cluster analysis of LHD public health informatics capacity revealed three groups of LHDs in terms of informatics capabilities, as shown in Table 2.

One cluster of LHDs reported the lowest use in five of the six informatics functionalities and are referred to as "Low" informatics capacity LHDs. A second cluster of LHDs had the second highest reported use in four of the six informatics functionalities and are referred to as "Mid" informatics capacity LHDs. A third cluster of LHDs had the highest reported use in five of the six of the informatics functionalities and are referred to as "High" informatics capacity LHDs.

Overall levels of LHD informatics capacity varied significantly across states (chi-square with 94 degrees of freedom = 247.2, p-value < .001, data not shown in tables). In addition, there was significant state-level variation in capacity for each of the six individual informatics functionalities.

Table 2: Clusters of Local Health Departments by Public Health Informatics Capacity (n=459)

Type of Functionality	Percent With Functionality				Difference Between Groups		
	Total	Low (n=112)	Mid (n=92)	High (n=255)	Low vs. Mid	Low vs. High	Mid vs. High
Immunization Registry	85.8%	49.1%	98.9%	97.3%	***	***	
Electronic Disease Registry	75.8%	18.8%	93.7%	93.3%	**	***	
Electronic Syndromic Surveillance System	66.5%	47.3%	60.9%	76.9%		***	
Electronic Lab Reporting	51.4%	17.9%	0.0%	84.7%		***	***
Electronic Health Records	25.1%	17.9%	19.6%	30.2%		***	*
Health Information Exchange	13.9%	5.4%	6.5%	20.4%		***	***

* p < .05 ** p < .01 *** p < .001

Usage varied significantly (p < .01) between low- and high-informatics capacity LHDs across all six types of functionalities. For the two most common functionalities (immunization registry and electronic disease registry), Mid- and High-informatics capacity LHDs had statistically equivalent levels of usage while the Low LHDs had significantly lower levels of usage. For the three least common functionalities (Electronic lab reporting, electronic health records, health information exchange), Low- and Mid-informatics capacity LHDs had statistically equivalent levels of usage while High LHDs had significantly higher levels of usage. A complete comparison of LHD awareness, consideration, and implementation of each informatics functionality is shown in the appendix, Table A2.

Informatics Capacity by LHD Characteristics

Public health informatics capacities were compared across the broad categories of LHD characteristics as described above. Findings are shown below in Table 3. Six of the 14 variable categories revealed significant differences between any of the three informatics categories.

Table 3: LHD Characteristics versus Public Health Informatics Capacity (Low, Mid, High)

LHD Characteristic	Percent or Mean (SD)				Difference Between Groups		
	Total	Low	Mid	High	Low vs. Mid	Low vs. High	Mid vs. High
Public Health Informatics Capacity	--	24.4%	20.4%	55.6%			
Population Served:							
< 50,000	47.7%	47.3%	57.6%	44.3%			**
50,000 – 499,999	39.4%	42.9%	38.0%	38.4%			
≥ 500,000	12.9%	9.8%	4.4%	17.3%			
Per Capita Expenditures ($):							
Total	47.85	45.17	44.90	48.81			
Local Sources	11.75	12.85	11.58	11.07			
State and Federal Sources	19.43	18.83	18.67	19.99			
Medicare/Medicaid Sources	9.60	6.13	3.21	12.18			**
Other Clinical Sources	2.52	2.68	3.29	2.21			
Workforce:							
Total FTEs per 10,000	5.5	5.0	5.4	5.9			
Employs any Information Systems Personnel	37.4%	32.2%	20.0%	45.7%			***
Organization, Governance & Leadership:							
Has Local Board of Health	70.0%	68.5%	73.9%	69.0%			
Freestanding, not part of HHS Agency	27.1%	29.3%	23.0%	28.1%			
Single county jurisdiction	75.4%	58.9%	79.4%	81.2%	**	***	
LHD has authority to set/impose fees	71.6%	79.5%	76.5%	66.3%			
Executive Director has Clinical Background	46.2%	32.1%	50.0%	51.0%	*	**	
Governance type:							
State	19.6%	25.0%	6.52%	22.0%			***
Local	72.3%	66.1%	90.2%	68.6%			
Shared	8.1%	8.9%	3.3%	9.4%			

* p < .05 ** p < .01 *** p < .001

Informatics Capacity by Types of Services Provided by LHD

Public health informatics capacities were compared across 42 public health services as described above. Findings are shown below in Table 4. Significant differences were found in provision levels across at least one of the three informatics capacities for 25 of the 42 services.

Comparison of LHD informatics capacity versus types of public health service provided revealed several notable and statistically significant patterns. First, LHDs with the lowest informatics capacity provided significantly fewer public health services than LHDs with mid-or high-levels of informatics capacity (p < .01). Second, for 25 of the 42 services, high-informatics capacity LHDs had significantly higher levels of provision than low-informatics capacity LHDs. Third, none of the 42 services saw low- or mid-informatics capacity LHDs with significantly higher levels of provision than high-informatics capacity LHDs.

All of the six categories of services shown in Table 4 saw at least one service with significantly different provision levels according to informatics capacity. Differences were most pronounced for services classified as Basic Population Focused (9 of 9 services had significantly different levels of provision across levels of LHDs informatics capacity) and were least pronounced for services classified as Specialized Individual Focused (1 of 5 services had significantly different levels of provision across levels of LHDs informatics capacity).

Table 4: Types of Public Health Services Provided by Public Health Informatics Capacity (Low, Mid, High)

Service	Percent Providing Service				Difference Between Groups		
	Total	Low	Mid	High	Low vs. Mid	Low vs. High	Mid vs. High
Individual Focused – Basic							
Adult Immunizations	92.8%	86.6%	92.4%	95.7%		**	
Childhood Immunizations	91.9%	83.0%	94.6%	94.9%	**	***	
EPSDT	31.8%	33.0%	23.9%	34.1%			
Family Planning	52.1%	36.6%	47.8%	60.4%		***	
MCH Home Visits	58.4%	50.0%	53.3%	63.9%		*	
WIC	65.6%	58.0%	60.9%	70.6%			
Individual Focused – Expanded							
Cancer Screening	34.9%	23.2%	26.1%	43.1%		***	**
Cardiovascular Disease Screening	30.3%	27.7%	28.3%	32.2%			
Diabetes Screening	36.8%	28.6%	32.6%	42.0%		*	
High Blood Pressure Screening	53.4%	47.3%	59.8%	53.7%			
Home Health Care	16.1%	19.6%	8.7%	17.3%			
Oral Health	24.8%	17.9%	18.5%	30.2%		*	
Prenatal Care	27.2%	21.4%	26.1%	30.2%			
Primary Care Services	11.8%	8.0%	5.4%	15.7%			*
School Health	35.1%	39.4%	28.3%	36.1%			
Well-Child Clinic	29.9%	25.9%	26.1%	32.9%			
Individual Focused – Specialized							
Behavioral/Mental Health Services	13.1%	12.5%	10.9%	14.1%			
HIV/AIDS Treatment	25.5%	22.3%	17.4%	29.8%			
Obstetrical Care	6.3%	0.9%	3.3%	9.8%		**	
School-Based Clinics	21.8%	20.5%	21.7%	22.4%			
Substance Abuse	31.2%	26.8%	23.9%	35.7%			
Population Focused – Basic							
Blood Lead Screening	59.0%	45.5%	57.6%	65.5%		***	
Communicable/Infectious Disease	92.8%	84.8%	94.6%	95.7%	*	***	
HIV/AIDS Screening	62.1%	47.3%	44.6%	74.9%		***	***
Nutrition	71.2%	61.6%	65.2%	77.7%		**	

STD Screening	66.2%	45.5%	55.4%	79.2%	***	***
Tuberculosis Screening	83.9%	72.3%	82.6%	89.4%	***	
Tuberculosis Treatment	76.7%	62.5%	75.0%	83.5%	***	
Tobacco Prevention	69.1%	60.7%	59.8%	76.1%	**	**
Unintended Pregnancy	50.3%	30.4%	43.5%	61.6%	***	**
Population Focused – Expanded						
Behavioral Risk Factors	39.9%	27.7%	37.0%	46.3%	**	
Chronic Disease Programs	52.7%	42.9%	45.7%	59.7%	**	
Maternal & Child Health Surveillance	62.1%	50.9%	56.5%	69.0%	**	
Physical Activity	56.2%	50.0%	48.9%	61.6%		
STD Treatment	61.7%	42.0%	53.3%	73.3%	***	**
Population Focused – Specialized						
Chronic Disease Epidemiology	46.8%	40.2%	42.4%	51.4%		
Injury Surveillance	27.5%	19.6%	23.9%	32.2%	*	
Injury Prevention	40.1%	25.9%	33.7%	48.6%	***	*
Mental Illness	16.1%	12.5%	9.8%	20.0%		
Substance Abuse Services	9.2%	11.6%	2.2%	10.6%		*
Syndromic Surveillance	53.6%	39.3%	43.5%	63.5%	***	**
Violence Prevention	23.3%	19.6%	13.0%	28.6%		**
Mean Number of Services Provided (out of 42)	18.7	15.8	17.0	21.3	***	***

* p < .05 ** p < .01 *** p < .001

Discussion

Public health informatics includes a broad range of systems and capacities aimed at strengthening public health practice, research, and learning [2]. Previous research has shown that while LHDs are known to use a wide range of IT systems and programs to meet their informatics needs, very little is known about the specific patterns of informatics use among LHDs [14]. This study presents a novel empirically-derived typology of LHD informatics usage patterns.

According to this study's empirically-derived typology, LHDs are clustered in three categories of informatics usage: Low (24.4%), Mid (20.4%), and High (55.6%). The LHDs with the lowest level of informatics usage had significantly lower levels of usage for all six functionalities assessed.

Rather than informatics capacity being somewhat evenly dispersed across the spectrum of LHDs, there is clear evidence of a substantial difference between the lowest- and highest-informatics capacity LHDs that is consistent across functionality types. For many functionalities, the differences were not only statistically significant but substantively important. For example, while 93% of high-informatics capacity LHDs utilized an electronic disease registry as of 2010, only 19% of low-informatics capacity LHDs did so—a nearly five-fold difference.

While high- and low-capacity LHDs differed across all six of the informatics capacities examined, a notable pattern emerged for mid-capacity LHDs. Namely, these LHDs were

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indistinguishable from high-capacity LHDs for the three most common informatics functionalities (immunization registries, electronic disease registries, and electronic syndromic surveillance systems) as both groups had relatively high levels of usage compared to low-informatics capacity LHDs. It is perhaps notable that immunization registries, electronic disease registries, and syndromic surveillance systems are frequently state-supported functionalities. However, for the three least common informatics functionalities (electronic lab reporting, electronic health records, health information exchange), mid-capacity LHDs had levels of usage on par with low-capacity LHDs.

A clear pattern of three levels of informatics capacities emerged: 1) LHDs that had consistently low levels of use across all forms of informatics, 2) LHDs that had consistently high levels of use across all forms of informatics, and 3) LHDs that had high levels of use of relatively common forms of informatics and low levels of use of relatively uncommon forms of informatics. One potential reason for these differences may relate to responsibility for system creation and or operation that can vary by state. For example, in some states the state public health department or its equivalent may be responsible for lab reporting, so LHDs may not have the authority to adopt an electronic lab reporting system, or it may appear seamless to the LHD because it is directly incorporated into their communicable disease or disease registry surveillance systems. This may help explain the relative abundance of LHDs with mid-informatics capacities reporting "No activity" in the area of electronic lab reporting. However, significant differences in informatics capacity were observed between mid- and high-informatics capacity LHDs across all functionalities, including those for which the LHD would have fuller control over adoption decisions, such as electronic health records.

Applications that are frequently state-supported (i.e., immunization registries, electronic disease registries, and electronic syndromic surveillance systems) may be somewhat simpler for LHDs to implement if these systems are operated at the state level and an LHD therefore operates more akin to information consumers than information brokers. For applications that are less-frequently state-supported, specific initiatives would require an LHD to have the capacity and leadership support to pursue. Thus cluster of LHDs with a mid-capacity in public health informatics may be distinguished, at least in part, due to the nature of the functionalities explored and the presence or absence of state-level activity in these areas.

Informatics adoption and use is complicated by factors both internal to an agency (e.g., public procurement processes) and external to an LHD (e.g., reliance on state- or national-level systems and actors). Thus, promoting robust LHD informatics capacity may require coordination of local, state, and national leadership. Given the autonomy that many states have in designing and implementing certain informatics systems, LHD leadership and information specialists may not always have the flexibility to custom-fit state- or nationally-run information systems to their local needs. Yet input from all levels of informatics system users can be essential for ensuring system success. For example the new national BioSense 2.0 system for electronic surveillance was designed after seeking input from state and local practitioners over a two-year period, with the specific intention of maximizing value for every level of the public health system [36]. State and national public health informatics leaders may want to specifically consider how best to coordinate their efforts to target LHDs with low-informatics capacity across the range of functionalities explored and LHDs with mid-informatics capacity in need of additional support for specific functionalities.

In considering where such support might be targeted, we identified multiple LHD characteristics that were significantly associated with informatics capacity. LHDs with the highest levels of public health informatics capacity tended to serve larger jurisdictions and have larger per capita amounts of Medicare and Medicaid expenditures. LHDs with the lowest levels of public health informatics capacity were less likely to be a single-county jurisdiction (and thus more likely to be multi-county, city-county, city, or another type) and were less likely to have an executive director with a clinical background. LHDs in a regional structure may not always have methods for cost or personnel sharing which would be essential to developing shared informatics capacity.

Previous surveys have shown an extremely strong correlation between LHD jurisdiction size and informatics-related activities [16], our study found that LHDs serving jurisdictions with fewer than 50,000 persons comprised roughly 45% of both the low- and high-informatics capacity clusters, suggesting that jurisdiction size alone does not differentiate low- versus high-informatics capacity. Rather, the observed patterns speak to the diverse impacts that an LHD's setting, finances, governance, and leadership may have on informatics capacity. An LHD's state was associated with significantly different levels of capacity overall and for all six individual functionalities and is potentially related to previous comments about state vs. local responsibility for information systems. Future national profiles of LHD informatics, such as those conducted by NACCHO, may provide additional contextual information in this area.

Public health service provision was strongly associated with informatics capacity. Public health service provision was almost invariably positively associated with informatics capacity. Statistically, there were two instances where a service had higher levels of provision at lower levels of informatics capacity (substance abuse services and violence prevention). There were 36 instances where a service had higher levels of provision at higher levels of informatics capacity. This provides strong evidence that informatics capacity and service provision are positively associated. Whether expanded service provision leads to expanded informatics capacity or vice versa remains to be shown.

Associations between service provision and informatics capacity were especially prevalent among certain categories of public health services (as categorized by Bekemier et al. [32]). For example, basic population-focused services showed stronger differences in service provision across the three levels of informatics capacity than specialized individual-focused services. Indeed, the three levels of informatics capacity saw starkly different service provision levels across many population-focused services. This relationship was not as strong for services oriented towards the individual. Given the nature of the informatics functionalities explored, this relationship—and in particular the strength of the relationship observed for population-focused service provision—is not unexpected. It emphasizes the role that informatics plays for specific public health services and the symbiotic nature of broad-based capacity for public health informatics and broad-based provision of population-focused services. This may mean that current informatics capacity at LHDs is oriented towards direct service provision rather than towards the collection, analysis, and reporting of data from external organizations [20].

Limitations

This study's findings should be viewed in light of its limitations. First, the typology of public health informatics capacity was based on a discrete set of six functionalities and their self-reported levels of use by LHDs. It is possible that LHDs may have systematically over- or under-reported informatics use, though given that several previous studies have found logical and

longitudinally consistent patterns in the NACCHO Profile assessment of LHD informatics usage [14,18], this misreporting is not hypothesized to severely bias findings. In addition, the sensitivity of typology classification to the specific services was explored partitioning the data into training and validation sets, with sample characteristics remaining consistent across both [31]. Second, since only one year of data were available, the extent to which informatics capacity changes or remains static over time is unknown and the causal nature of the relationships examined cannot be proven. Future study with subsequent waves of NACCHO data may shed additional light on this issue. Third, imperfect data were available to capture state- versus local-authority pertaining to each of the service areas relevant to the six functionalities (e.g., state-level authority for lab reporting). While a thorough review of the state-by-state authorities for services pertaining to all six of the informatics functionalities was outside of the scope of this study, we did explore state-level variation for functionalities not hypothesized to be determined by state-level authority or availability (e.g., electronic medical records) and found consistent variation across all informatics functionalities examined. Fourth, the measures employed for both informatics use and service provision do not capture information about effectiveness, merely the presence or absence of a given functionality/service.

Conclusion

National patterns in the use of public health informatics have been poorly understood to date. With the growing importance of LHD ability to receive, analyze, and report out electronic data in concert with a range of partner organizations, a better understanding of the current capacity for and patterns in the use of public health informatics is essential. This study's empirically-derived typology represents a novel conceptualization of department-wide informatics capacity.

Findings showed strong evidence that informatics usage is clustered within LHDs, with some departments demonstrating consistently high levels of use of all six informatics functionalities explored. Other departments have lower capacity across all six functionalities. A third group demonstrated high levels of use for relatively common informatics functionalities and low levels of use for relatively uncommon informatics functionalities. A major distinguishing factor for low- versus high-informatics capacity LHDs is breadth of public health services provided by the department. Provision of population-focused services are especially highly correlated with higher informatics capacity.

This may suggest two broad areas of need if we are to strengthen informatics capacity on a national level. First, LHDs with low levels of informatics capacity may need support or technical assistance that is cross-cutting across multiple informatics areas. Special consideration may also be necessary for how these LHDs can maximize the value of informatics to their work and the communities they serve, given their lower levels of service provision relative to high-informatics capacity LHDs. Second, for the group of LHDs with mid-level informatics capacity, special consideration of strategies to promote adoption and use of less common technologies (e.g., electronic health records or health information exchange) may be most beneficial. These departments already have strong capacity for the more common informatics capacities, but targeted work is likely to be more beneficial than broad-based approaches. Consideration to state-level factors may be especially important for these LHDs.

The findings suggest that LHDs with high levels of informatics capacity also have relatively higher levels of service provision. Future research to establish the direction of this relationship or studies to explore the linkages between LHD informatics applications and community partners

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may help build upon the empirical finding that LHDs cluster into three distinct patterns of informatics capacity. Developing solutions tailored to these patterns may help to build and expand this capacity for LHDs to serve as information brokers within their jurisdictions.

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