

HEALTH SYSTEM CAPACITY AND INFRASTRUCTURE FOR ADOPTING INNOVATIONS IN VENOUS THROMBOEMBOLIC DISEASE CARE

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ABSTRACT

Background

Diagnosis and treatment for venous thromboembolic disease (VTE) have evolved considerably through diagnostic and therapeutic innovations. Despite the considerable potential for enhancing care, however, the extent to which these innovations are being adopted in usual care is not known. We conducted interviews of health system managers and selected providers within health regions and hospitals for all of Canada to document the extent of infrastructure available for provision of optimal diagnostic care and therapy.

Methods

We studied system infrastructure for care of VTE disease in 10 provinces and 3 territories and all 94 health regions therein. We interviewed all acute care hospitals in Canada. We documented key elements of system infrastructure at the hospital level for 658 individual acute-care hospitals.

Results

There is considerable variation across Canada in the availability of key infrastructure for the diagnosis and management of VTE disease. Larger provinces tended to have D-dimers available in a large proportion of hospitals whereas smaller ones were more likely to have them sent to centralized analysis facilities. All provinces had some facilities for advanced diagnostic imaging but the number and extent of 24/7 availability was quite variable (ranging from 0% to 90%). Only 6 provinces had regions with availability of dedicated early and/or long term outpatient clinics for VTE disease.

Conclusions

Infrastructure in Canada for optimal VTE disease care was suboptimal through 2009 and not entirely in step with the evidence. These sorts of system infrastructure shortfalls limit the extent to which health care providers can deliver optimal evidence-based care to their patients. Such nation-wide evaluations of health system infrastructure should be undertaken internationally to better characterize quality of care and potential for improvement.

INTRODUCTION

The approach to diagnosis and treatment for venous thromboembolic disease (VTE) (ie. both deep vein thrombosis (DVT) and pulmonary embolism (PE)) has evolved considerably, through diagnostic and therapeutic innovations. Specific innovations include the development of low molecular weight (LMW) heparins^{1,2}, medications that permit out-patient treatment for selected patients, new clinical prediction algorithms for estimating probability of disease^{3,4}, new blood tests for ‘D-dimers’⁵ (i.e. markers of clotting activity) that potentially enhance the diagnostic process, and new computed tomography (CT) scanning technology for detecting clots in both the lungs and limbs that also potentially add efficiency to the diagnostic process⁶. For longer-term oversight of anticoagulation management, anticoagulation monitoring clinics have also been associated with improved anticoagulation control⁷. All of these innovations are endorsed and incorporated into the high profile American College of Chest Physicians (ACCP) guidelines for diagnosis and management of VTE^{8,9}.

Despite the considerable potential for enhancing care, the extent to which these innovations are being adopted in usual care is not known. To achieve uptake by clinicians involved in care of individual patients, there is a need for system infrastructure to permit optimal evidence-based care. Without the availability of specific infrastructure and services, well-meaning providers are not able to provide specific services.

Recognizing this, we undertook surveys and interviews of health system managers and targeted providers within regions and hospitals for all of Canada to document the extent of infrastructure for:

- a) Optimal diagnostic care (-- specifically D-dimers and imaging modalities (CT, ventilation-perfusion (VQ), venography, pulmonary angiography and doppler ultrasonography)) and
- b) Therapy (formulary access to LMW heparins, anticoagulation clinics, critical pathways)

Surveys were conducted both at the level of hospitals (with survey of all acute-care hospitals in Canada) and at the level of geographic health regions. The resulting work provides a transportable template for undertaking health system infrastructure evaluations in other countries and/or jurisdictions.

METHODS

We studied system structure for care of VTE disease in 10 provinces and 3 territories, and each of the defined 94 health regions within the studied jurisdictions. We have considered health regions to be geographic units useful for description and visualization of data on maps, and not necessarily uniformly administered health systems for which care of VTE disease would be explained by a single administrative structure. We also targeted 658 individual acute-care hospitals to document key elements of system infrastructure at the hospital level. All existing acute-care hospitals in Canada were surveyed if they provide acute care services to adults (i.e., individuals ≥ 18 years of age) and if they were facilities that have an emergency room.

Dates and procedure for data collection

Data collection was performed by a nurse research assistant and ran from January 2008 through October 2009. All acute care hospitals in Canada were contacted and stakeholders were identified and interviewed. Stakeholder interviews were conducted in English or French, and these varied in duration from 10 to 30 minutes. An algorithmic multi-step procedure was followed to identify relevant stakeholders within each of the surveyed health regions and/or hospitals (details available from authors upon request). The surveyed individuals had to have knowledge of VTE disease care and related services. If they did not have such knowledge, we asked them to refer us to an alternate person.

Hospital-level

We collected specific system structural characteristics at the level of individual hospitals including: 1. availability of D-dimer assays in the hospital laboratories or as a rapid bedside test; 2. specific type(s) of D-dimer assays available; 3. existence of formal diagnostic critical pathways to guide providers in the integrated use of clinical prediction algorithms, D-dimer assays, and diagnostic imaging; 4. availability of specific diagnostic imaging modalities such as ventilation-perfusion (V/Q) scanning, spiral CT scanning for performance of pulmonary embolism protocols and CT venography, doppler ultrasonography, venography and pulmonary angiography and 5. hospital policies regarding availability of the above-mentioned imaging studies after-hours or on weekends.

Region-level

We simultaneously collected structural characteristics at the level of health regions including: 1. existence of outpatient follow-up clinics dedicated to the oversight of early outpatient management of patients with VTE disease; 2. existence of outpatient anticoagulation clinics and/or home self-monitoring programs for the longer-term warfarin anticoagulation management of patients with VTE disease; 3. geographic locations of any existing outpatient follow-up clinics or anticoagulation management clinics; 4. specific low molecular weight agents available regionally via the provincial or territorial formulary; and 5. existence of accessible mechanisms to offset outpatient costs of expensive low molecular weight heparins for patients who do not have drug plans.

ANALYSIS

Simple descriptive analyses were undertaken. For each data system infrastructure element, we present global Canada-wide data on the proportions of regions or hospitals that have a particular structural attribute along with binomial 95% confidence intervals for those proportions. We also present detailed tabulations by region and hospital on the presence/absence of each of the specific structural elements assessed.

We used geographic information systems (GIS) to produce maps of Canadian health system infrastructure by region and by hospital. Each hospital location was geocoded by postal code using the Postal Code Conversion File (Statistics Canada, 2006) within Esri

ArcGIS 9.2 (Redlands, CA). A figure was created that showed the distribution of facilities with limited and 24/7 service for VQ scanning, CT scanning, doppler ultrasound, and pulmonary angiography.

RESULTS

Our findings globally demonstrate considerable variation across Canada in the availability of key system infrastructure elements required for optimal VTE disease diagnosis and therapy. Our response rate was 100% as every hospital was contacted and frequent calls were made until a stakeholder could be interviewed.

D-dimer Assays and Hospital-based Diagnostic Imaging Resources

Figure 1 presents information on the availability and types of D-dimer assays available or collected by hospital in Figure 1. There is much variation in availability or collection and sending of D-dimers across hospitals. Larger provinces tended to have D-dimers available on-site in most hospitals whereas smaller provinces were more likely to have them collected and sent to centralized analysis facilities. The Yukon territories, meanwhile, had minimal availability of access to D-dimer testing, either on-site or through collection and sending off-site for analysis.

Table 1 presents data on the presence of hospital-based diagnostic imaging infrastructure by province. Again, there is considerable variation across hospitals and jurisdictions. All provinces had some facilities for advanced diagnostic imaging but the number of

facilities and extent of 24/7 availability was quite variable. The northern territories, meanwhile, had limited availability of diagnostic imaging resources, either 24/7 or for limited hours. The proportion of hospitals with at least one of the VTE imaging modalities available (time limited or 24/7) varied across provinces/territories from a low of 0% (0/2 hospitals) in Nunavut to a high of 89.9% (89/99 hospitals) in Quebec (Table 1).

Decision Support Tools

We present decision support tools by province in Table 2. Again there is considerable variation in the number of hospitals that have diagnostic critical pathways or other similar decision-support tools. Most provinces have some hospitals where such tools are in use, but PEI and the northern territories did not have facilities that host such tools for VTE disease.

Diagnostic Imaging

Figure 2 shows the distribution of facilities with time-limited and/or 24/7 access to diagnostic imaging services for VTE disease across Canada. Panel A and D of Figure 2 show that VQ scanning and pulmonary angiography are primarily available in the larger urban centres across the country. In contrast, Panel B shows that CT scanning is more widely available across the country and that most locations offer 24/7 service. Panel C shows that although Doppler ultrasonography is available throughout the country, it is only a limited service in many areas.

Outpatient Clinics and Home Monitoring Programs

Table 3 presents information on regional outpatient clinic and home monitoring by province. Only 6 provinces had regions with dedicated early OP clinics and long term OP clinics for VTE disease. Dedicated VTE disease home monitoring programs were even less available, with only 23% of the regions reporting having these.

DISCUSSION

This study was a significant data collection undertaking, with all 658 Canadian acute-care hospitals with emergency rooms contributing data to our survey. The study findings reveal that infrastructure for VTE care innovations is present in Canada and that new diagnostic and therapeutic strategies are becoming available. Their availability, however, is not universal and considering that our survey was undertaken in 2009, several years after new evidence emerged on the diagnostic and therapeutic innovations that we assessed, there is considerable lag in infrastructure availability relative to the new evidence. Our findings highlight the non-uniformity of Canada's health care system, and the challenge of providing optimal care, and optimal infrastructure for care, to all of the residents of a geographically expansive country. Health system infrastructure is a necessary prerequisite to optimal process of care, and it is only when structure and process are optimized that optimal outcomes can be achieved. These findings, and the approach taken to produce them, provide a template for the conduct of large-scale system infrastructure assessment.

Our finding of variation in the availability of health services across the country is not entirely new. There is much research discussing the concept of small area variation, concluding that health information about a total population is a prerequisite for decision-making and planning in health care¹⁰. Variations in care often arise from overutilization of some services in high-use areas, a scenario of supply-sensitive care. Supply-sensitive care can be seen as any intervention whose frequency of use depends largely on the availability of the resource to the patient¹¹. There is also much research into geography and access to health care in cancer care and cardiac care¹². VTE disease care is a bit different from both cancer and cardiac care, because a larger pool of providers is involved in provision of care, and because VTE disease care is less often managed through referral to centralized tertiary care centres. Aside from pulmonary angiography, most of the imaging and testing required for VTE disease care is not a tertiary service. Yet, across the country, there is non-uniform availability of diagnostic and therapeutic infrastructure that may be limiting the ability of providers to deliver optimal evidence-based care.

This is an example of the Donabedian model on display. Donabedian, widely acknowledged to be one of the leading thinkers in health services research, introduced a model for measuring quality based on system theory in 1966¹³⁻¹⁵. According to this theory, healthcare is a system with objectives and components. In Donabedian's framework, the three components of healthcare quality are *structure*, *process* and *outcome*. The structure is the environment in which health care is provided and includes material and health resources, operational factors, and organizational characteristics of

the healthcare facility (relatively stable factors). The process is the method by which healthcare is provided and includes the giving and receiving of care by the provider and healthcare system, whereas the outcome is the consequence of healthcare and includes the health status of patients and communities. According to the model, processes are constrained by the structures in which they operate, and it is this latter point that is underlined with the non-uniform availability of services assessed in this study.

To the extent that some jurisdictions and hospitals have incomplete availability of services, the considerations and/or decisions relate to either increasing locally available services, increasing hours of availability or ensuring that patient transfer mechanisms are in place for regionalized care delivery.

There are some limitations with our study. First data collection for the entire country has been a major undertaking. As a result we acknowledge that there may be some changes that have been implemented since late 2009. It is also possible that our data collection process may have even triggered some local actions (because, anecdotally, a number of the individuals surveyed indicated interest in initiating quality improvement interventions toward the end of our study interviews). Second, we did not assess locally available transfer mechanisms. Patient transfer mechanisms can mitigate some of the challenges associated with lack of locally available infrastructure. It is, however, notable that our study is a Canada-wide study, for which we assessed availability of services in all acute-care hospitals and health regions. These limitations need to be highlighted as an important caveat, and correspondingly, our results need to be qualified as being a baseline

assessment that identifies local opportunities for health system decision makers to undertake infrastructure enhancement that could produce better processes, which in turn can lead to better outcomes. For frontline providers, meanwhile, this study provides information that can inform their advocacy for local system enhancements and associated quality improvement.

This study comprehensively documents the extent of infrastructure for optimal diagnostic and therapeutic care of VTE disease across Canada. Even with the time lag, this study provides a template for evaluation of system structure that can be adapted to other countries and potentially also other clinical areas. There are geographic inequalities in service availability for VTE across hospitals, and therefore downstream implications to process and outcome. This study's findings underline how process of care and eventual optimized care are constrained by the infrastructure that the system possesses. Care innovations like those for VTE disease challenge health systems to remain in step with evidence for optimal disease care.

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CONFLICT OF INTEREST

All authors have no conflicts of interest to declare.

SPONSOR ROLE

The Canadian Institutes of Health Research had no involvement in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the report for publication. The authors were able to access and independently analyze the data, and prepare and publish the manuscript without sponsor interference.

CONTRIBUTOR STATEMENT

Danielle Southern participated in finalizing the study methodology, performed the analysis and was the principal writer of the manuscript. Bill Ghali conceived the project, oversaw the data collection and analysis and participated in all phases of the writing. Jasmine Poole helped implement the study, worked on finalizing the methodology and

contributed to the editing of the manuscript. Alka Patel performed the geographic methods used in the study and reviewed all manuscript drafts. Nigel Waters supervised the geographic methods used in the study and reviewed all manuscript drafts. Louise Pilote supervised the implementation of the study and reviewed all manuscript drafts. Russell Hull participated in the editing of the manuscript. All of the authors approved the final version of the manuscript.

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TABLE 1 Availability of Hospital-based Diagnostic Imaging Resources N(%)

	PROVINCE												
	BC	AB	SK	MB	ON	PQ	NB	NS	PE	NL	NT	NU	YK
# Hospitals	71	94	66	70	166	99	21	32	7	25	4	2	7
V/Q Scan													
24/7	3 (4.2)	10 (10.6)	2 (3.0)	0	10 (6.0)	49 (49.5)	4 (19.0)	4 (12.5)	1 (14.3)	2 (8.0)	0	0	0
Limited	11 (15.5)	1 (1.1)	2 (3.0)	6 (8.6)	54 (32.5)	0	1 (4.8)	3 (9.4)	0	2 (8.0)	0	0	0
Spiral CT													
24/7	25 (35.2)	14 (14.9)	7 (10.6)	3 (4.3)	69 (41.6)	72 (72.7)	10 (47.6)	9 (28.1)	0	9 (36.0)	1 (25.0)	0	1 (14.3)
Limited	1 (1.4)	8 (8.5)	4 (6.1)	8 (11.4)	10 (6.0)	0	0	0	1 (14.3)	1 (4.0)	0	0	0
Doppler													
24/7	23 (32.4)	13 (13.8)	11 (16.7)	4 (5.7)	52 (31.3)	87 (87.9)	8 (38.1)	12 (37.5)	1 (14.3)	11 (44.0)	0	0	0
Limited	16 (22.5)	17 (18.1)	2 (3.0)	13 (18.6)	95 (57.2)	0	4 (19.0)	5 (15.6)	1 (14.3)	2 (8.0)	3 (75.0)	1 (50.0)	1 (14.3)
Pulmonary													
Angiography													
24/7	7 (9.9)	6 (6.4)	5 (7.6)	0	18 (10.8)	36 (36.4)	7 (33.3)	2 (6.3)	0	4 (16.0)	0	0	0
Limited	4 (5.6)	2 (2.1)	0	3 (4.3)	13 (7.8)	0	2 (9.5)	1 (3.1)	1 (14.3)	1 (4.0)	0	0	0
Venography													
24/7	7 (9.9)	12 (12.8)	10 (15.2)	1 (1.4)	15 (9.0)	30 (30.3)	5 (23.8)	6 (18.8)	0	9 (36.0)	0	0	0
Limited	10 (14.1)	11 (11.7)	0	10 (14.3)	45 (27.1)	0	6 (28.6)	3 (9.4)	1 (14.3)	1 (4.0)	0	1 (50.0)	1 (14.3)
Any Imaging (24/7 or Limited)	28 (39.4)	15 (16.0)	12 (18.2)	5 (7.1)	86 (51.8)	89 (89.9)	11 (52.3)	12 (37.5)	1 (14.3)	11 (44.0)	1 (25.0)	0 (0.0)	1 (14.3)

TABLE 2 Decision Support Tools

Province	# Hospitals	# Hospitals with Diagnostic Critical Pathway	# Hospitals with Computer Prompts
British Columbia	71	12 (16.9%)	1 (1.4%)
Alberta	94	39 (41.5%)	10 (10.6%)

Saskatchewan	66	5 (7.6%)	0
Manitoba	70	1 (1.4%)	0
Ontario	166	40 (24.1%)	7 (4.2%)
Quebec	99	41 (41.4%)	2 (2.0%)
New Brunswick	21	16 (76.2%)	2 (9.5%)
Nova Scotia	32	15 (46.9%)	0
Prince Edward Island	7	0	0
Newfoundland & Labrador	25	3 (12.0%)	0
Nunavut	1	0	0
Northwest Territories	4	3 (75.0%)	0
Yukon	2	0	0

TABLE 3 Regional Resources & Clinics

Province	# Regions	# Regions with Early OP clinics	# Regions with Long Term OP clinics	# Regions with Home Programs	# Regions with Home monitoring
British Columbia	5	0	0	0	0
Alberta	9*	5 (55.6%)	4 (44.4%)	2 (22.2%)	0
Saskatchewan	13	2 (15.4%)	1 (7.7%)	0	1 (7.7%)
Manitoba	11	1 (9.1%)	1 (9.1%)	0	0
Ontario	14	0	0	0	0
Quebec	18	17 (94.4%)	17 (94.4%)	0	0
New Brunswick	7	2 (28.6%)	3 (42.9%)	1 (14.3%)	0
Nova Scotia	9	2 (22.2%)	1 (11.1%)	1 (11.1%)	0
Prince Edward Island	1	0	0	0	0
Newfoundland & Labrador	4	0	0	0	0
Nunavut	1	0	0	0	0
Northwest Territories	1	0	0	0	0
Yukon	1	0	0	0	0

* 9 regions at time of data collection

FIGURE LEGEND

Figure 1 - Availability and type of d-dimer test available by hospital in 10 Canadian provinces and 3 territories

Figure 2 - Availability of hospital-based diagnostic imaging services across Canada.

FIGURE 1

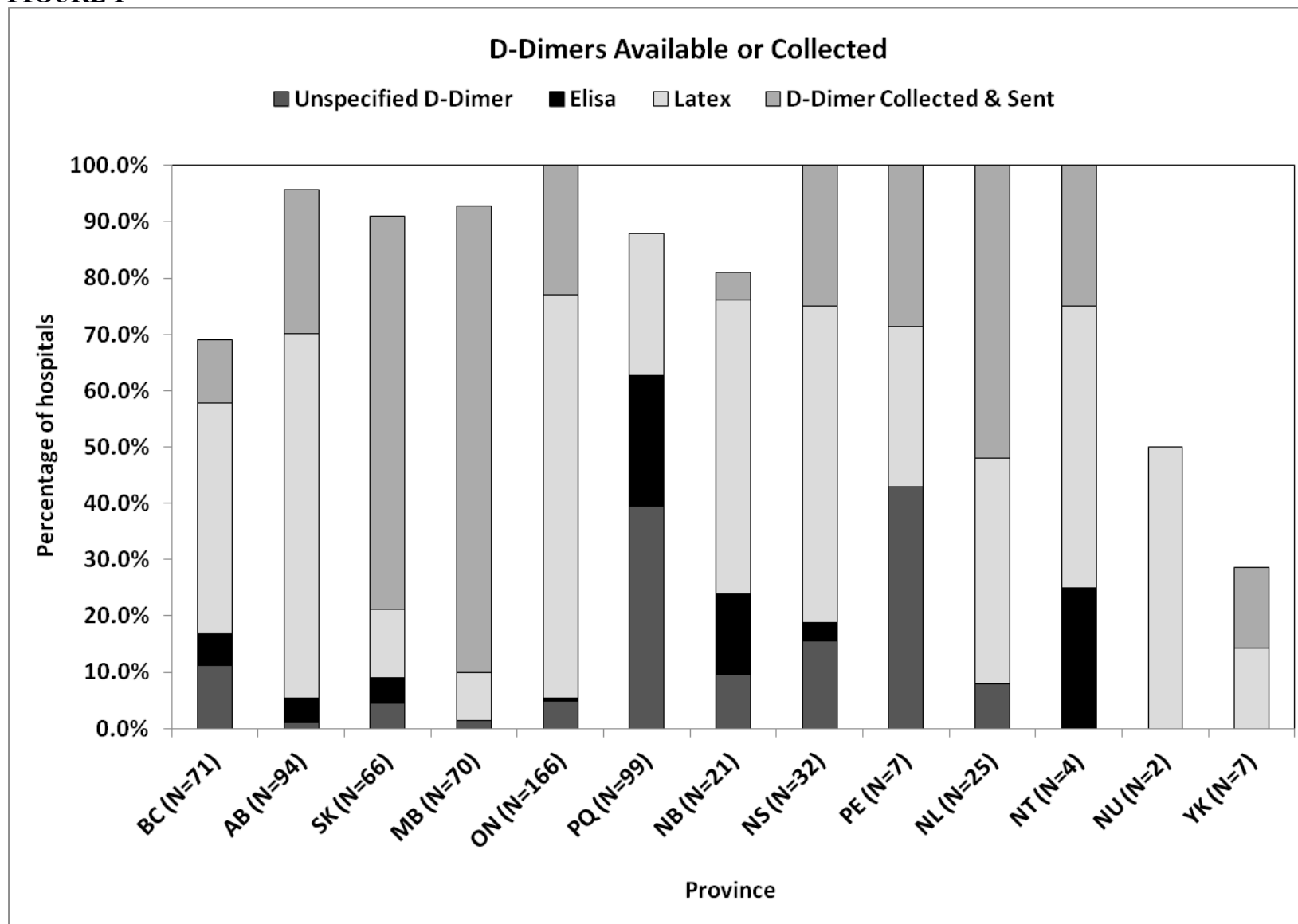


FIGURE 2

