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Patterns of Clinical Information Systems Sophistication: An Empirical Taxonomy of European Acute Care Hospitals

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Outline

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- Research objectives
- Conceptual framework
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Background

- "In all OECD countries total spending on healthcare is rising faster than economic growth" putting pressure on government budgets (OECD, 2010)
- Govenments are taking initiatives such as:
  - Structural reforms of healthcare systems
  - Accelearating the adoption and implementation of ICT and especially Electronic Health Record (EHR) which are at the heart of major initiatives
- In the European Union (EU)
  - Population ageing will continue to increase demands on healthcare and long-term care systems
  - Hospitals account for at least 25% of health expenditure, and are at the heart of ongoing reforms (Dexia and HOPE, 2009)
    - Hospitals play a central role in healthcare systems and represent an important share of healthcare spending
    - Acute care hospitals represent more than half of the total number of hospitals (65% in average) (HOPE, 2012)

Research objectives

- Health IT adoption and use is a major priority for the European Commission (EC)
  - Two eHealth Action Plans: 2004-2010; 2012-2020

➢ Understanding HIT adoption within hospitals is of paramount importance for policy makers and researchers

- The present study pursues the following objectives:
  - Characterize EU hospitals with regard to adopted EHR key CIS functionalities
  - Investigate whether the patterns of EHR functionalities adoption are influenced by certain hospitals' contextual characteristics

Conceptual Framework

EHR Functionalities	European Survey
Clinical documentation	
Demographics characteristics of the patient	✓
Physicians' notes (clin. notes)	✓
Reason for encounter	✓
Nursing assessment	
Problem list/Diagnoses	✓
Medication list	✓
Prescription list	✓
Allergies	✓
Immunizations	✓
Vital signs	✓
Symptoms (reported by patient)	✓
Medical history	✓
Disease management or care plan	✓
Discharge summaries	
Advanced directives	
Results viewing	
Laboratory reports	✓
Radiologic test results (reports)	
Radiologic test results (images)	✓
Diagnostic-test results	
Diagnostic-test images	
Consultant reports	
Computerized provider-order entry	
Laboratory tests	✓
Radiologic tests	✓
Medications	
Consultation requests	
Nursing orders	

"There is no consensus on what functionalities constitute the essential elements necessary to define an electronic health record in the hospital setting" (Jha et al., 2009, p. 1630)

Methods (1/2)

- Data used was collected by the EC (Joint Research Center, Institute for Prospective Technological Studies)
- Purpose of the survey: *to benchmark the level of eHealth use in acute care hospitals in 28 EU member states, Iceland and Norway* (JRC, 2014, p. 10)
  - The initial database composed of 1753 acute care hospitals
  - Only clinical variables with missing values < 9% were included
  - Data was missing completely at random (Little's MCAR test was not significant)
  - Due to missing values we retained 1056 hospitals and 13 out 17 variables

Methods (2/2)

- Factor Analysis
  - Bartlett' test of sphericity ($\chi 2(78)=6603.435$, $p < 0.001$)
  - Kaiser-Meyer-Olkin measure of sampling adequacy KMO=0.95
    - The matrix was adequate for factor analysis (Kaiser, 1974)
- Two-step procedure (Balijepally et al., 2011; Ketchen and Shook, 1996; Milligan, 1980)
  - 1: Use a hierarchical algorithm to identify the "natural" number of clusters and define the clusters' centroids
  - 2: Use the results of 1) as initial seeds for nonhierarchical clustering
- Validation of the cluster solution
  - Discriminant analysis

Cluster Analysis Results (1/5)

- Factor Analysis

Rotated factors matrix for EHR functionalities (n= 1056)	Factor loading	Cronbach Alpha
Factor 1- Clinical documentation		
Symptoms	0.828	0.9
Encounter notes, clinical notes	0.789	
Medical history	0.775	
Allergies	0.732	
Vital signs	0.728	
Ordered test	0.69	
Disease management or care plans	0.68	
Problem list/diagnoses	0.624	
Factor 2- Results viewing		
Radiology test results (reports)	0.899	0.79
Radiology test results (images)	0.873	
Lab. test results	0.669	
Factor 3 - Medication and prescription lists		
Medication list	0.871	0.8
Prescription list	0.849	
Total variance explained = 66.15%		

Cluster Analysis Results (2/5)

- Determination of the number of clusters
  - Inspection of the dendrogram
    - 100% of the sample, then 66%, 50% and 33%
      - 3 or 4-cluster solutions
  - Compararison of the Kappa (Ward vs K-means)

➢ 4-cluster solution emerged as optimal solution

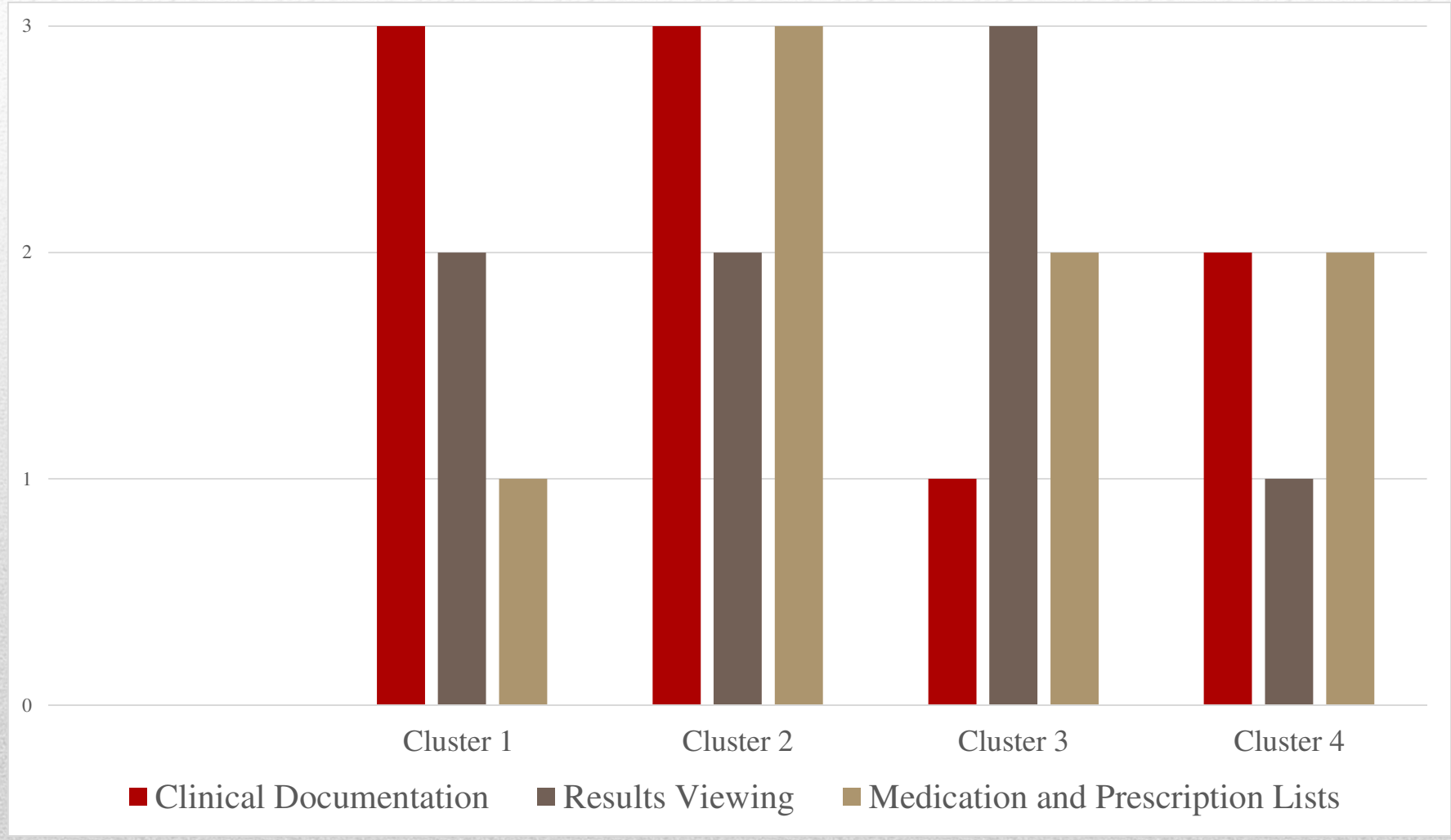
- Validation – Discriminant analysis
  - Cross-validation approach with 2 sub-samples (analysis=60%; holdout=40%)
    - Hit ratio for the holdout sample=95% > 1.25*Cpro=38% (Hair et al., 2010)
      - Cpro = proportional chance criteria

Cluster analysis (3/5)

Clusters	**1** **n=199** **19%** **mean**	2 n=479 45% **mean**	**3** **n=200** **19%** **mean**	**4** **n=178** **17%** **mean**	**ANOVA** **F**
Configuration factors					
Clinical documentation	**H**	**H**	**L**	**M**	
	0.491_{a}	0.497_{a}	-1.463_{c}	-0.2436_{b}	471.73***
Results viewing	**M**	**M**	**H**	**L**	
	$0.372_{a,b}$	0.326_{b}	0.538_{a}	-1.898_{c}	982.92***
Medication and prescription lists	**L**	**H**	**M**	**M**	
	-1.404_{c}	0.553_{a}	0.076_{b}	-0.004_{b}	368.19***

[a,b,c] Within rows, different subscripts indicate significant ($p < 0.05$) pair-wise differences between means on Tamhane's T2 (post hoc) test. H (High), M (Moderate), L (Low) indicate relative magnitude of the group means on each varaiable across seven clusters. *: $p < 0.05$; **: $p < 0.01$ ***: $p < 0.001$

Cluster analysis (4/5)



Cluster analysis (5/5)

Clusters	1 n=199 19% mean	2 n=479 45% mean	3 n=200 19% mean	4 n=178 17% mean	ANOVA F
Hospital's level in the transition from paper-based systems to a fully electronically-based system. (1=totally paper-based, 9=totally electronically-based)	M 5.41_{b}	H 6.47_{a}	L 4.75_{c}	M $5.10_{b,c}$	82.52***

[a,b,c] Within rows, different subscripts indicate significant ($p < 0.05$) pair-wise differences between means on Tamhane's T2 (post hoc) test. H (High), M (Moderate), L (Low) indicate relative magnitude of the group means on each varaiable across seven clusters. *: $p < 0.05$: **: $p < 0.01$ ***: $p < 0.001$.

Discussion

- 4 – configurations empirically and conceptually grounded
  - Great heterogeneity
    - Nature and number of EHR dominant functionalities
  - Only about half (45%) of the sample are able to make available most of a basic EHR functionalities
- Dominance of *clinical documentation* functionalities
  - *2 clusters accounting for 64% of the sample scored high*

Breakdown hosp. charact. by cluster

Clusters Hosp. Charact.		1 (n=199) 19% %O(%E)	2 (n=479) 45% %O(%E)	3 (n=200) 19% %O(%E)	4 (n=178) 17% %O(%E)	χ^2
University	Yes (15)	4(3)	7(7)	3(3)	1(3)	6.93
	No (85)	21(16)	34(38)	14(16)	16(14)	
Non-University Teaching	Yes (44)	13(8)	18(20)	8(8)	5(7)	24.57***
	No (56)	12(11)	22(25)	8(11)	14(10)	
Having a formal IT strategic plan	Yes (64)	16(12)	28(29)	11(12)	9(11)	22.72***
	No (36)	8(7)	13(16)	6(7)	9(7)	

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Breakdown of hosp. size by cluster

Clusters	1	2	3	4	
	(n=199)	(n=479)	(n=200)	(n=178)	
	19%	45%	19%	17%	χ^2
Size - # beds(% Expected)	%O(%E)	%O(%E)	%O(%E)	%O(%E)	
<101 (19)	3(4)	7(9)	3(4)	6(3)	
101 <X < 250 (29)	7(6)	12(13)	4(6)	6(5)	47***
251 <X < 750 (38)	11(7)	15(17)	6(7)	6(6)	
>750 (13)	4(2)	7(6)	2(2)	1(2)	

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Breakdown of hosp. IT budget by cluster

Clusters	1	2	3	4	
	(n=199)	(n=479)	(n=200)	(n=178)	χ^2
	19%	45%	19%	17%	
IT budget % hosp. budget	%O(%E)	%O(%E)	%O(%E)	%O(%E)	
<1% (35)	7(7)	13(16)	8(7)	7(6)	
1 <=X < 3 (50)	14(10)	21(23)	8(10)	7(9)	33.87***
3.1 <=X <5 (10)	3(2)	4(5)	1(2)	2(2)	
>=5 (5)	1(1)	3(2)	0(1)	1(1)	

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Breakdown of hosp. IT outsourcing budget by cluster

Clusters	1 (n=199)	2 (n=479)	3 (n=200)	4 (n=178)	
IT outsourcing % IT budget	19%	45%	19%	17%	χ^2
	%O(%E)	%O(%E)	%O(%E)	%O(%E)	
0% (20)	4(4)	9(9)	3(4)	4(3)	
X < 25% (47)	14(21)	18(9)	9(4)	6(3)	21.55*
25 <=X <=49 (18)	4(3)	7(8)	3(3)	4(3)	
50 <=X <=74 (8)	2(2)	3(4)	1(2)	2(1)	
>=75 (7)	1(1)	3(3)	2(1)	1(1)	

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$

Contribution and Conclusion

- Better understanding of EHR functionalities available in EU hospitals
  - Empirically based taxonomy that goes beyond normative discourse
- Reveals wide differences regarding EHR functionalities availability among EU hospitals
  - High scores on EHR functionalities
    - (2/3) 1cluster; (1/3) 2clusters; (0/3) 1 cluster
- Reveals a separation of Medication and Prescription lists from Clinical documentation through Factor Analysis
- Reveals only a moderate effect of hospital's characteristics onEHR functionalities availability
- Offers a foundation for future research

THANK YOU

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