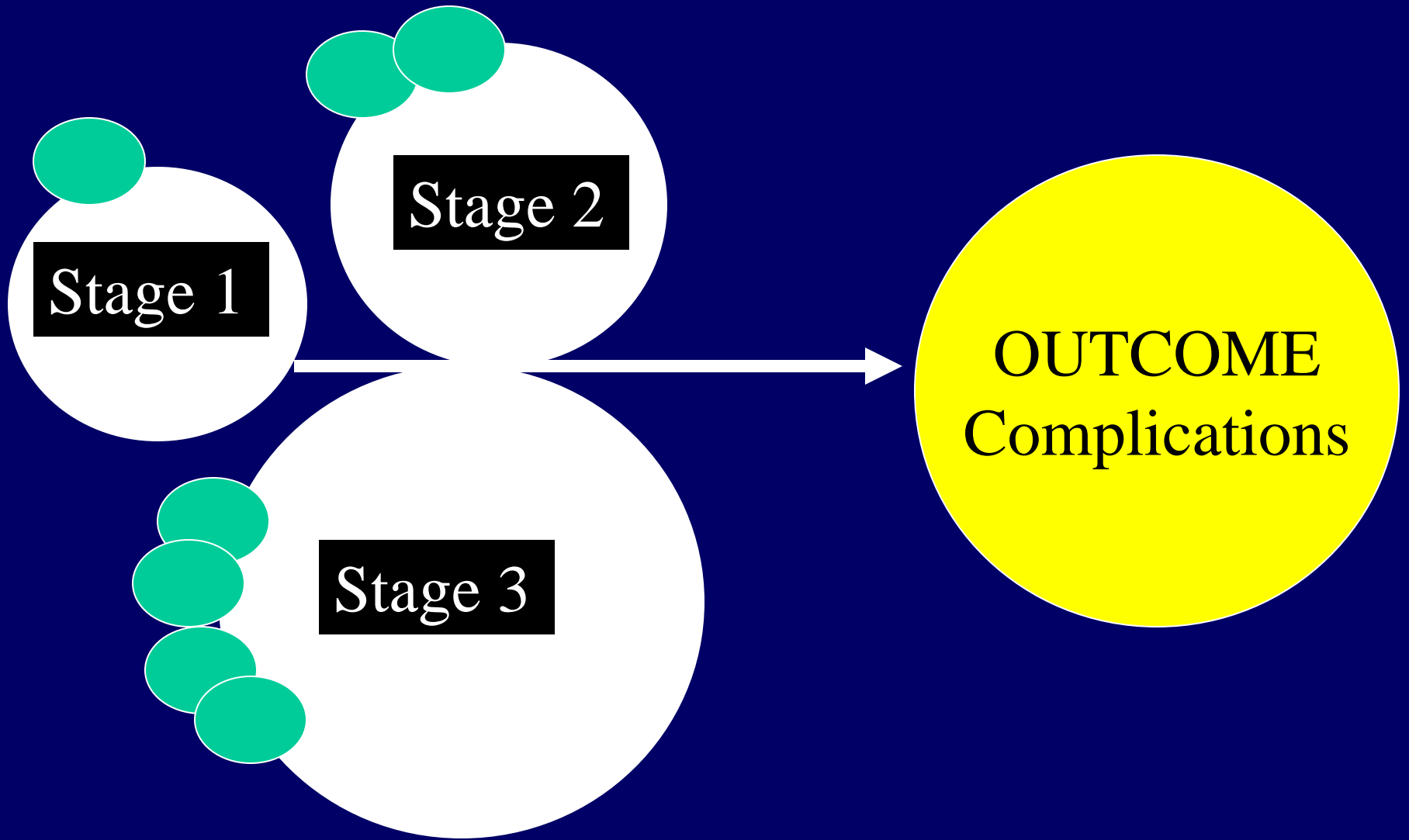


# Defining and Validating Comorbidities for Risk Adjustment

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Associate Professor  
University of Calgary

For Regina Conference 2010



Stage 1

Stage 2

Stage 3

OUTCOME  
Complications

# Comorbidity and Risk Measurement

ICD book Chapters

Disease Grouping: DRG, CMG, CRG, ACG

Individual chronic conditions

Condition counting

Comorbidity indexes

Physician visits

Prescriptions

# Charlson Comorbidity Index

559 hospital charts for patients admitted to medical services

RR:

<1.1 excluded

1.2- 1.4: Weight=1

1.5- 2.4: Weight=2

2.5- 3.4: Weight=3

6.0+ : Weight=6

1 year mortality

## **Charlson Comorbidity Index** *(J Chron Dis 1987,40:337)*

1. AIDS
2. Cerebrovascular disease
3. Chronic pulmonary disease
4. Congestive heart failure
5. Dementia
6. Diabetes
7. Diabetes with complication
8. Hemiplegia or paraplegia
9. Malignancy
10. Metastatic solid tumor
11. Mild liver disease
12. Moderate or severe liver disease
13. Myocardial infarction
14. Peptic ulcer disease
15. Peripheral vascular disease
16. Renal disease
17. Rheumatologic disease

## **Deyo's ICD9CM Codes** *(J Clin Epidemiol 1992,45:613)*

1. 042-044.9
2. 430-438
3. 490-496, 500-505, 506.4
4. 428
5. 290
6. 250-250.3, 250.7
7. 250.4-250.6
8. 344.1, 342-342.9
9. 140-172.9, 174-195.8, 200-208.9
10. 196-199.1
11. 571.2, 571.5, 571.4-571.49
12. 572.2-572.8
13. 410, 412
14. 531-534, 531.4-531.7, 534.4
15. 443.9, 441, 785.4, V43.4, 38.48
16. 582-582.9, 583-583.7
17. 710.0, 710.1, 710.4, 714.0

*Elixhauser Comorbidities*  
(*Medical Care*, 1998;36:8-27)

1,779,167 Inpatients in California

```
graph TD; A[1,779,167 Inpatients in California] --> B[LOS<br/>$ Charge<br/>In-hospital mortality];
```

The diagram consists of two rectangular boxes with white borders. The top box contains the text '1,779,167 Inpatients in California'. A thick white arrow points downwards from the bottom center of this box to the top center of a second box. The second box contains three lines of text: 'LOS', '\$ Charge', and 'In-hospital mortality'.

LOS

\$ Charge

In-hospital mortality

## *Elixhauser's 30 Comorbidities*

Congestive heart failure

Cardiac arrhythmias

Valvular disease

Pulmonary circulation disorders

Peripheral vascular disorders

Hypertension, uncomplicated

Hypertension, complicated

Paralysis

Other neurological disorders

Chronic pulmonary disease

Diabetes, uncomplicated

Diabetes, complicated

Hypothyroidism

Renal failure

Liver disease

Peptic ulcer disease excluding bleeding

AIDS

Lymphoma

Metastatic cancer

Solid tumor without metastasis

Rheumatoid arthritis/collagen vascular diseases

Coagulopathy

Obesity

Weight loss

Fluid and electrolyte disorders

Blood loss anemia

Deficiency anemias

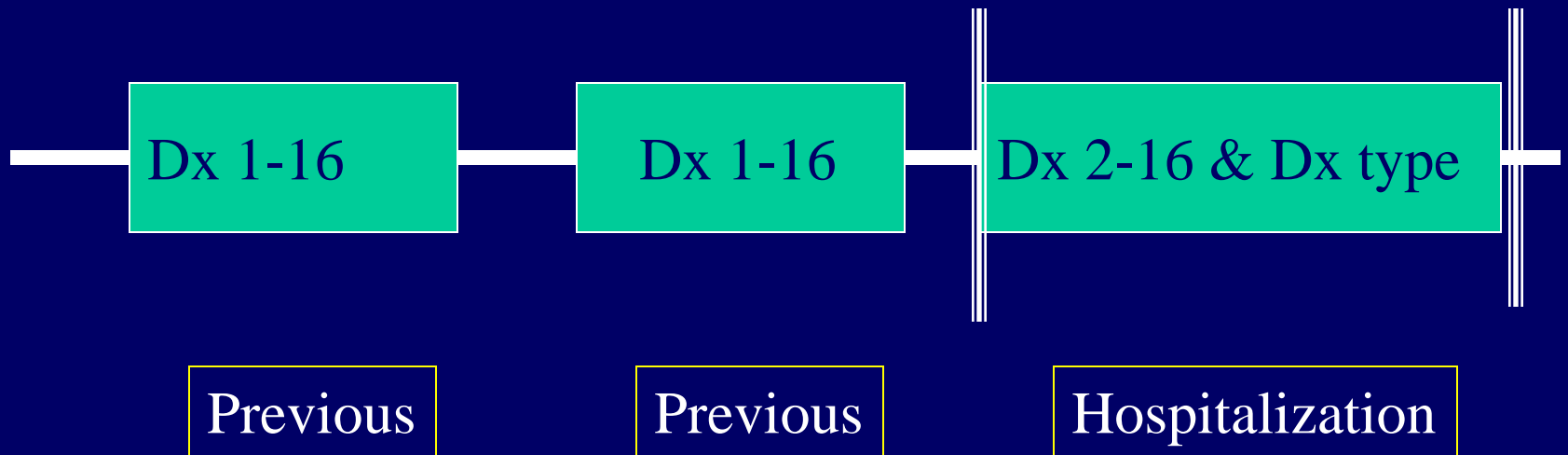
Alcohol abuse

Drug abuse

Psychoses

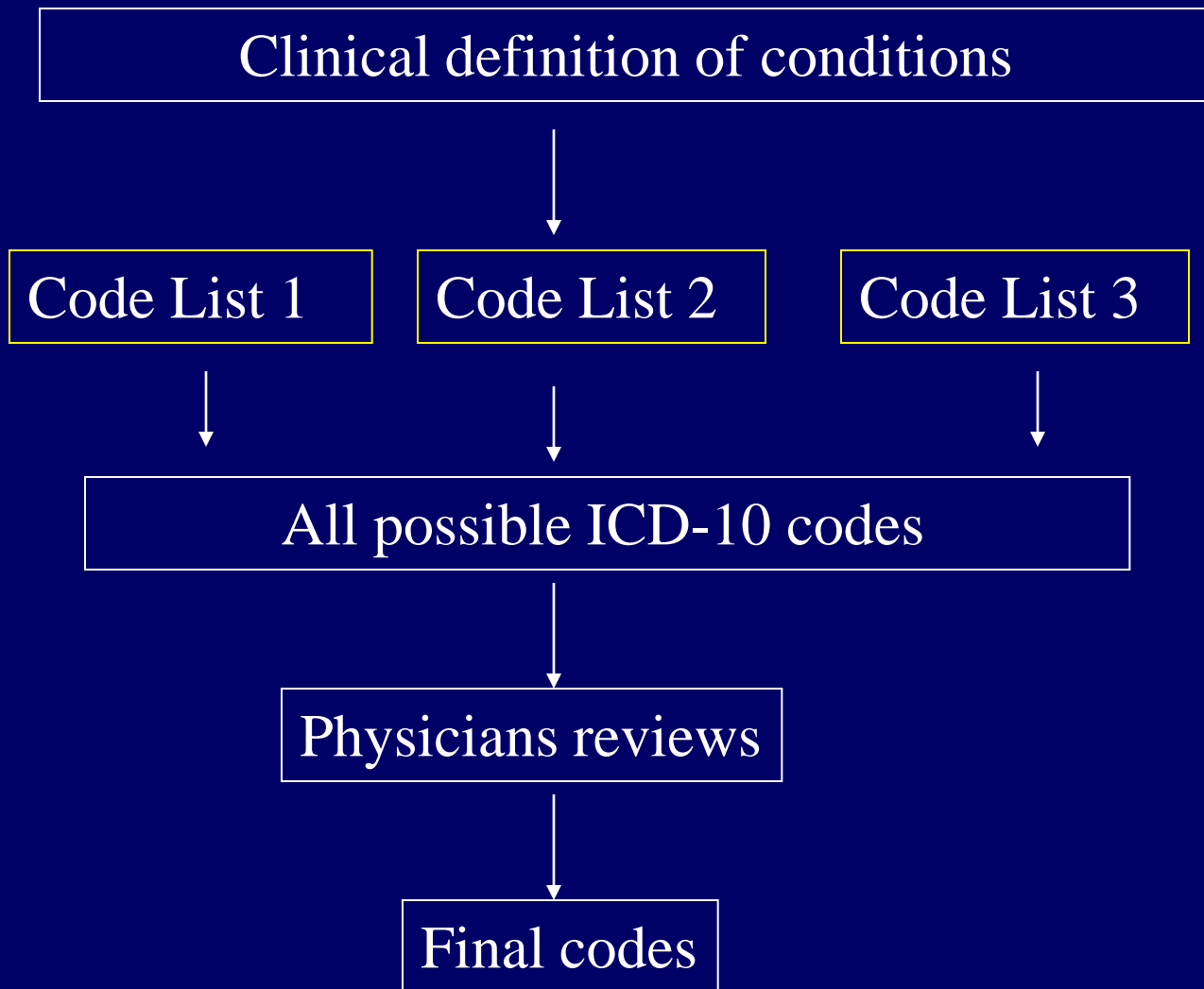
Depression

# Defining Comorbidities



Development ICD-10 coding  
definitions for comorbidities

# ICD Definition Development



- ❖ ICD-10
- ❖ Deyo's ICD-9-CM
- ❖ Updated ICD-9-CM

**TABLE 1.** ICD-9-CM and ICD-10 Coding Algorithms for Charlson Comorbidities

Comorbidities	Deyo's ICD-9-CM	ICD-10	Enhanced ICD-9-CM
Myocardial infarction	410.x, 412.x	I21.x, I22.x, I25.2	410.x, 412.x
Congestive heart failure	428.x	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x, P29.0	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428.x
Peripheral vascular disease	443.9, 441.x, 785.4, V43.4 Procedure 38.48	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9	093.0, 437.3, 440.x, 441.x, 443.1–443.9, 47.1, 557.1, 557.9, V43.4
Cerebrovascular disease	430.x–438.x	G45.x, G46.x, H34.0, I60.x–I69.x	362.34, 430.x–438.x
Dementia	290.x	F00.x–F03.x, F05.1, G30.x, G31.1	290.x, 294.1, 331.2
Chronic pulmonary disease	490.x–505.x, 506.4	I27.8, I27.9, J40.x–J47.x, J60.x–J67.x, J68.4, J70.1, J70.3	416.8, 416.9, 490.x–505.x, 506.4, 508.1, 508.8
Rheumatic disease	710.0, 710.1, 710.4, 714.0–714.2, 714.81, 725.x	M05.x, M06.x, M31.5, M32.x–M34.x, M35.1, M35.3, M36.0	446.5, 710.0–710.4, 714.0–714.2, 714.8, 725.x
Peptic ulcer disease	531.x–534.x	K25.x–K28.x	531.x–534.x

## Coding Algorithms for Defining Comorbidities in ICD-9-CM and ICD-10 Administrative Data

*Hude Quan, MD, PhD,\*† Vijaya Sankararajan, MD, MPH, FACP,‡ Patricia Halfon, MD,§ Andrew Fong, BCOMM,\* Bernard Burnand, MD, MPH,§ Jean-Christophe Luthi, MD, PhD,§ L. Duncan Saunders, MBBCh, PhD,¶ Cynthia A. Beck, MD, MAsc,\*|| Thomas E. Feasby, MD,\*\* and William A. Ghali, MD, MPH,\*†,††*

**Objectives:** Implementation of the International Statistical Classification of Disease and Related Health Problems, 10th Revision

(ICD-10) data. ICD-9-CM mor-

resulting algorithms.

**Methods:** ICD-10 coding algorithms were developed by "translation" of the ICD-9-CM codes constituting Deyo's (for Charlson comorbidities) and Elixhauser's coding algorithms and by physicians' assessment of the face-validity of selected ICD-10 codes. The process of carefully developing ICD-10 algorithms also produced modified and enhanced ICD-9-CM coding algorithms for the Char-

**Results:** Among 56,585 patients in the ICD-9-CM data and 58,805 patients in the ICD-10 data, frequencies of the 17 Charlson comorbidities and the 30 Elixhauser comorbidities remained generally

[www.chaps.ucalgary.ca/sas.htm](http://www.chaps.ucalgary.ca/sas.htm)

9-CM coding algorithm, 0.860 for the ICD-10 coding algorithm, and 0.859 for the enhanced ICD-9-CM coding algorithm, 0.868 for the original Elixhauser ICD-9-CM coding algorithm, 0.870 for the ICD-10 coding algorithm and 0.878 for the enhanced ICD-9-CM coding algorithm.

**Conclusions:** These newly developed ICD-10 and ICD-9-CM comorbidity coding algorithms produce similar estimates of comor-

## Cross-National Comparative Performance of Three Versions of the ICD-10 Charlson Index

*Vijaya Sundararajan, MD, MPH,\*† Hude Quan, MD, PhD,‡§ Patricia Halfon, MD,¶  
Kiyohide Fushimi, MD, PhD,|| Jean-Christophe Luthi, MD, PhD,¶ Bernard Burnand, MD, MPH,¶ and  
William A. Ghali, MD, MPH,‡§\*\* for the International Methodology Consortium for Coded Health  
Information (IMECCHI)*

**Objective:** The Charlson comorbidity index has been widely used for risk adjustment in outcome studies using administrative health data. Recently, 3 International Statistical Classification of Diseases, Tenth Revision (ICD-10) translations have been published for the Charlson comorbidities. This study was conducted to compare the predictive performance of these versions (the Halfon, Sundararajan, and Quan versions) of the ICD-10 coding algorithms using data from 4 countries.

**Methods:** Data from Australia (N = 2000–2001, max 25 diagnosis codes), Canada (N = 2002–2003, max 16 diagnosis codes), Switzerland (N = 1999–2001, unlimited number of diagnosis codes),

Japanese data, the median c-statistics were 0.712 (Quan), 0.709 (Sundararajan), and 0.694 (Halfon) using individual comorbidity coefficients. In general, the probability distributions between the Quan and the Sundararajan versions overlapped, whereas those between the Quan and the Halfon version did not.

**Conclusions:** Our analyses show that all of the ICD-10 versions of the Charlson algorithm performed satisfactorily (c-statistics 0.70–0.86), with the Quan version showing a trend toward outperforming the other versions in all data sets.

*(Med Care 2007;45: 1210–1215)*

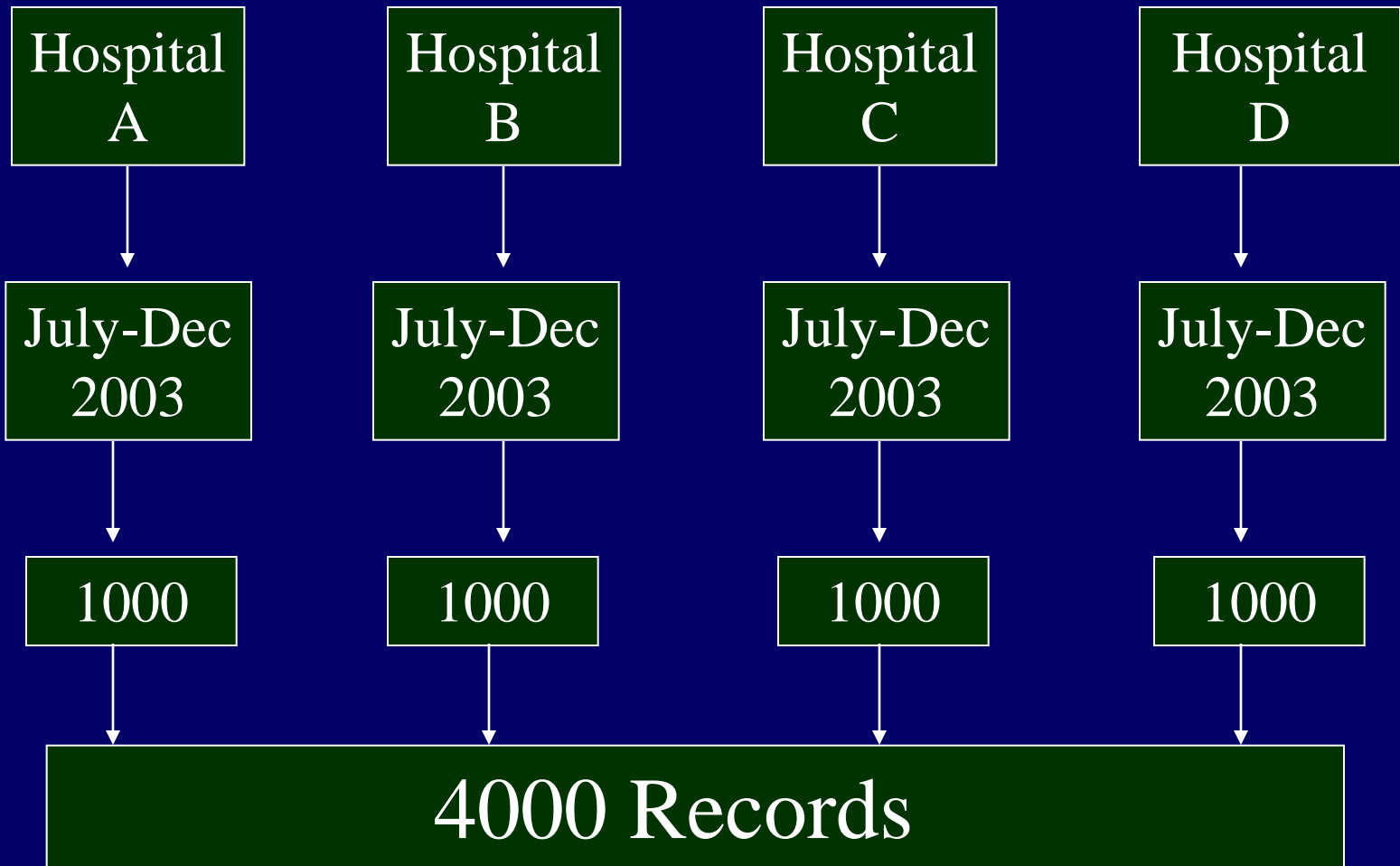
# Mortality results for four countries

Score	Canada	Switzerland	Australia	Japan
0	0.36	0.51	0.37	1.53
1	2.43	2.83	2.81	2.60
2	4.24	3.09	5.80	3.75
3	8.51	5.68	8.24	6.25
4	10.26	7.57	11.05	6.55
5	16.54	12.30	15.96	8.13
6+	13.70	11.40	16.43	16.76
C- statistics	0.836	0.772	0.840	0.701

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# Validating ICD-9/10 coding definitions for conditions

# Alberta Teaching Hospitals



4000 Records  
July – Dec 2003



Data  
ICD-10-CA

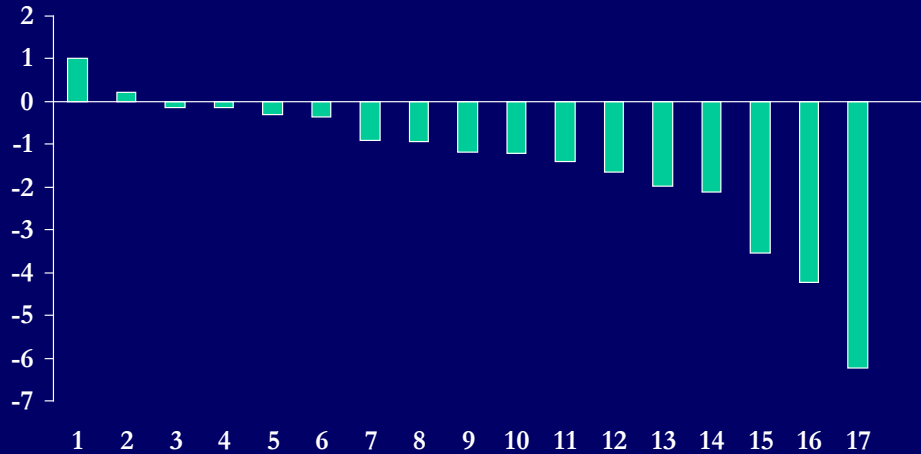
Data  
Chart  
Review

Data  
ICD-9-CM

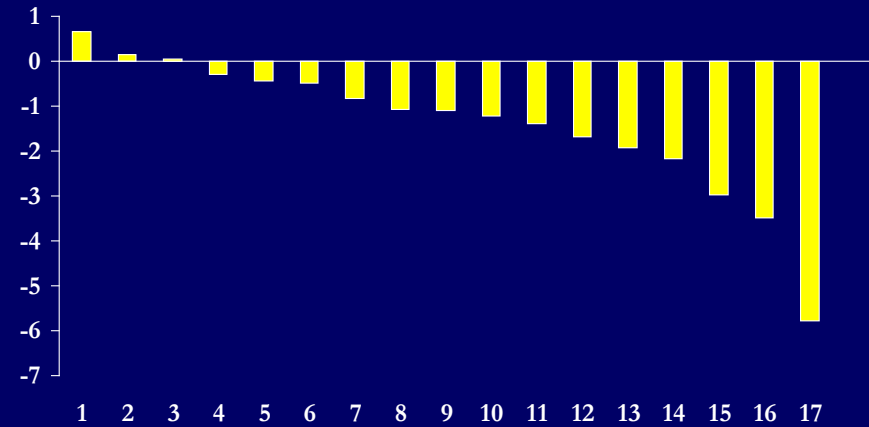


# Difference in prevalence (%)

**% in ICD 10 data - % in charts**

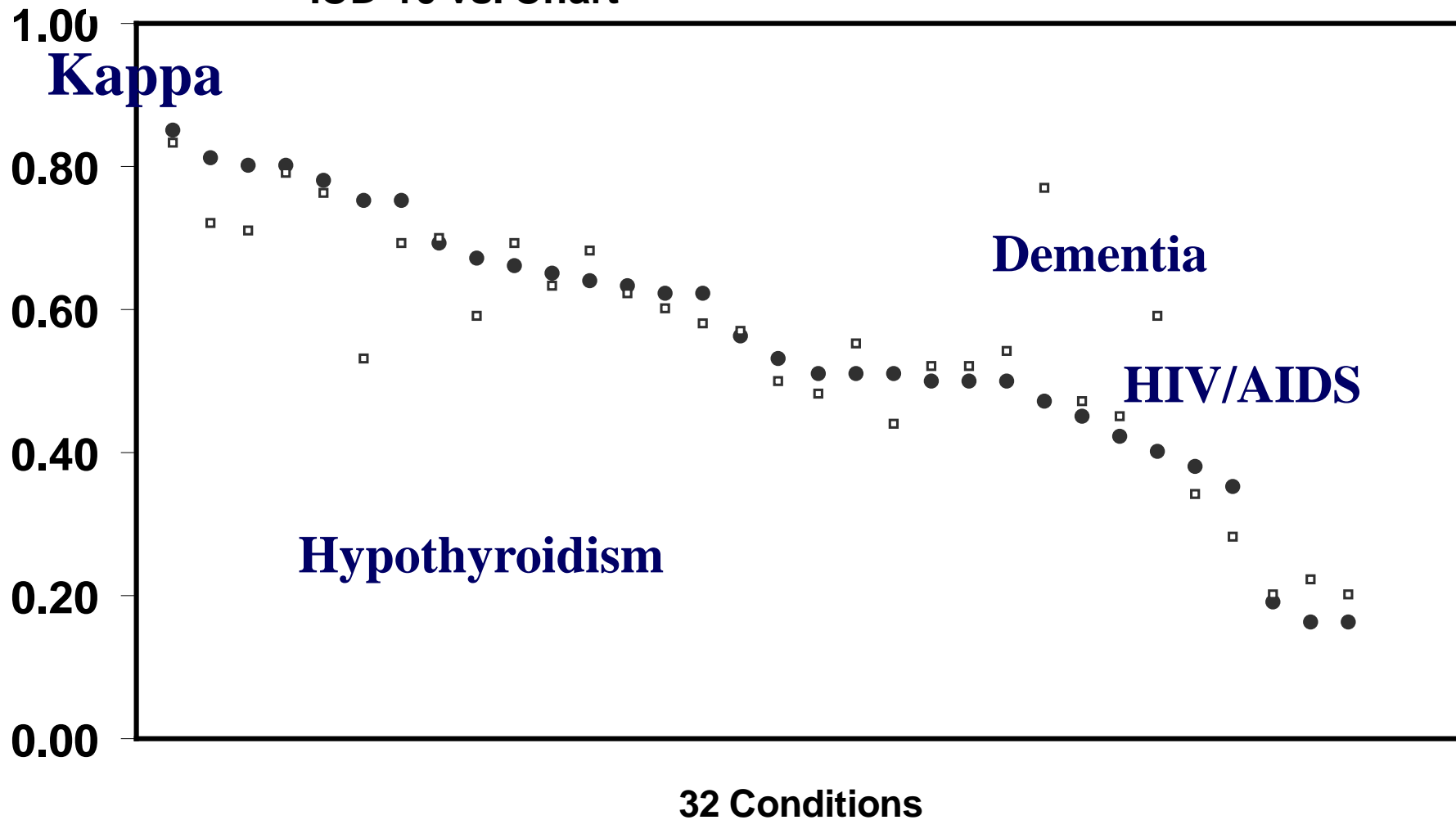


**% in ICD 9 CM data - % in charts**



● ICD-9-CM vs. Chart

□ ICD-10 vs. Chart



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# Methods

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## Assessing Validity of ICD-9-CM and ICD-10 Administrative Data in Recording Clinical Conditions in a Unique Dually Coded Database

*Hude Quan, Bing Li, L. Duncan Saunders, Gerry A. Parsons, Carolyn I. Nilsson, Arif Alibhai, and William A. Ghali for the IMECCHI Investigators*

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**Objective.** The goal of this study was to assess the validity of the International Classification of Disease, 10th Version (ICD-10) administrative hospital discharge data and to determine whether there were improvements in the validity of coding for clinical conditions compared with ICD-9 Clinical Modification (ICD-9-CM) data.

**Methods.** We reviewed 4,008 randomly selected charts for patients admitted from January 1 to June 30, 2003 at four teaching hospitals in Alberta, Canada to determine the presence or absence of 32 clinical conditions and to assess the agreement between ICD-10 data and chart data. We then recoded the same charts using ICD-9-CM and determined the agreement between the ICD-9-CM data and chart data for recording those

# Updating and Validating Charlson Index Score

International Methodology Consortium for Coded Health Information  
[www.IMECCHI.org](http://www.IMECCHI.org)

Optimal methodologies for deriving knowledge and wisdom from health data.

## *Updating Charlson Index and Score*

55,929 Inpatients in Calgary

```
graph TD; A[55,929 Inpatients in Calgary] --> B[1 year mortality]; B --> C[Comorbidities and Weights]; C --> D["In hospital mortality in Canada, Australia, NZ, Japan, France, Switzerland"];
```

1 year mortality

Comorbidities and Weights

In hospital mortality in Canada,  
Australia, NZ, Japan, France,  
Switzerland

Variables	Hazard Ratio	Updated weight	Charlson weight
Myocardial infarction	0.99*	0	1
Congestive heart failure	1.91	2	1
Peripheral vascular disease	1.10*	0	1
Cerebrovascular disease	1.10*	0	1
Dementia	2.39	2	1
<b>Chronic pulmonary disease</b>	1.28	1	1
<b>Rheumatologic disease</b>	1.30	1	1
Peptic ulcer disease	1.08*	0	1
Mild liver disease	1.94	2	1
Diabetes without chronic complication	1.12*	0	1
Diabetes with chronic complication	1.22	1	2
<b>Hemiplegia or paraplegia</b>	2.26	2	2
Renal disease	1.43	1	2
<b>Any malignancy, including leukemia and lymphoma</b>	2.28	2	2
Moderate or severe liver disease	3.83	4	3
<b>Metastatic solid tumor</b>	6.01	6	6
AIDS/HIV	3.69	4	6
Maximum score#		24	29

**C-statistic for risk adjusted logistic regression predicting mortality among 55,929 patients with age $\geq$ 18 years in Calgary, Canada**

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<b>Mortality</b>	<b>12 updated comorbidities</b>	<b>17 Charlson comorbidities</b>	<b>Updated score</b>	<b>Charlson score</b>
<b>In-hospital</b>	<b>0.882</b>	<b>0.884</b>	<b>0.881</b>	<b>0.879</b>
<b>In 30 day</b>	<b>0.884</b>	<b>0.886</b>	<b>0.883</b>	<b>0.881</b>
<b>In 1 year</b>	<b>0.897</b>	<b>0.899</b>	<b>0.896</b>	<b>0.894</b>

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## C-statistics for logistic regression model with inhospital mortality

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Score from	Canada	France	Japan	Australia	New Z	Switzerland
12 updated comorbidities	0.828	0.878	0.727	0.825	0.831	0.869
17 Charlson comorbidities	0.825	0.882	0.723	0.808	0.836	0.876

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