

Using Health Information to Enhance Musculoskeletal Rehabilitation for Older Persons

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CS 793, March 7, 2011

InfoRehab

Who we are:


- InfoRehab is a program of research funded by the Canadian Institutes of Health Research.
- Investigators from universities across Canada (the University of Toronto, University of British Columbia, University of Alberta, University of Waterloo, University of Ottawa, University of Calgary, and University of Western Ontario)
- Collaboration with a broad range of stakeholders (consumers, hospital, home care, long-term care, professional associations, policy-makers, experts in knowledge translation)



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Our rationale...

- Older clients, often with multiple morbidities, challenge our ability to deliver high quality care
- 'The transfer of timely and accurate information across settings is critical to the execution of effective care transitions' (Coleman & Fox, 2004)
- The effective use and transfer of health information is particularly critical in MSK rehabilitation.
- Relevant health information systems are available, but their potential to inform care planning and decision-making has not been realized.
- Better use and management of existing health information systems could improve rehabilitation of older persons with MSK disorders



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Our goal:


To enhance musculoskeletal (MSK) rehabilitation through more effective use of health information across the continuum of care.



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Health Information


- Focusing on:
 - Health information collected through standardized health assessment systems
 - Frail older persons, particularly those with musculoskeletal disorders, such as hip fracture




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Today

- Health assessment information for older persons
- Barriers to effective use of health information in care planning, with a focus on rehabilitation in home care
- Using statistical analysis and data mining of health assessment data, to answer clinical and policy questions




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HEALTH ASSESSMENT INFORMATION FOR OLDER PERSONS

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A Frail Older Person: Mrs. Aasen



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Mrs. Aasen (1)

- 87 years old
- Lives alone in own apartment
- Walking independently
- Homemaking 1X week – bathing & housework
- Fall at MD's office → hip fracture

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Mrs. Aasen (2) Comorbidities

- Hypertension many years
- Diabetes 6 yrs – control poor, frequent hypoglycemia
- Small stroke several years ago
- IHD – angina 6 months
- OA hands, knees and shoulder
- Diabetic retinopathy – blind L eye, cataract R eye
- Chronic renal impairment, creatinine 147
- Urinary urgency
- Constipation
- Poor appetite ↓ weight 15 lb 1 year

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Mrs. Aasen (3) Medications

- Acetaminophen 500 mg qid
- Beclomethasone aqueous nasal spray
- Codeine 15 mg qid
- Diltiazem CD 300 mg qd
- Ferrous Gluconate 300 mg tid
- Glyburide 5 mg daily
- Nitroglycerin Transdermal 0.4 mg/hr patch
- Pioglitazone 15 mg daily
- Docusate Sodium 100 mg bid
- Senna conc. 8.6 mg 2 daily
- Warfarin 1 mg daily
- 5 PRNs

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Mrs. Aasen (4)

No delirium post-op
MMSE 27/30
Weight 52 kg
Admission FIM: 71/126

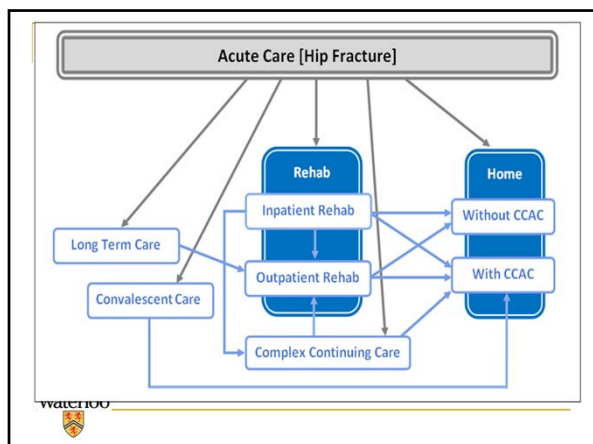
Goals:

- (1) Walking
- (2) ADL and IADL
- (3) Stairs
- (4) Tub Transfers

New Issues:

- (1) Son died shortly after transfer
- (2) At risk of depression
- (3) UTI and urinary retention
- (4) Post-op anemia
- (5) Osteoporosis

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Frail Older Persons

- Multiple, complex problems
- Not all goals/outcomes are relevant for all patients
- Care typically involves multiple care providers and multiple care settings
- Same outcomes can be positive or negative, depending on the patient or situation
- Quality of life often more relevant than survival or length of life

Need to Re-think Clinical Information Systems (Gray, et al., 2009)

- Increasing population of older persons – often with multiple diseases/comorbidities, receiving care from multiple providers across multiple care settings
- Integration and coordination of care and services are key
- Traditional clinical information systems tend to focus on a limited set of problems
- Need a complex, multidimensional view of patients
- Need information that can move with individuals as they move across care settings

What type of assessment system would accommodate the complexity and individualized nature of health problems in frail older persons?



A couple options

- Individualized measures
- Standardized measures

An Individualized Measure: Goal Attainment Scaling

- Developed by Kiresuk and Sherman in 1968
- Key Features:
 - 5-Point Scale of Individualized Potential Outcomes
 - Summary Goal Attainment Score
- Research and Clinical Applications

Sample GAS Guide

Attainment Levels	Mobility	Discharge Planning
Much less than expected (-2)	Chairfast	On rehab unit > 6 weeks ✓
Less than expected (-1)	Walks ~ 5 metres with walker ✓	Discharged to nursing home
Expected level (0)	Walks ~ 10 metres with walker, 3 weeks *	Home with daily home support, 4 weeks
Better than expected (+1)	Walks ~ 20 metres with walker	Home with home support, 2-3 times/week *
Much better than expected (+2)	Mobile inside house with cane, walker modest distance outside	Home with weekly home support
Comment		Patient does not wish nursing home placement



The Goal Attainment Score

$$GA \text{ SCORE} = 50 + \frac{10 \sum (w_i x_i)}{\sqrt{.7 \sum w_i^2 + .3 (\sum w_i)^2}}$$



Standardized Measures

- “Three Generations” (Gray, et al., 2009)
- 1st generation: battery of assessment tools for specific uses



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Save Save and Exit Exit Print

MINI-MENTAL STATE EXAM

Name: HALPERT, JIM Age: 26 years Sex: M Date: 2006/02/23

Diagnosis: Medications:

SCORE MAX

ORIENTATION

1. Name, year, season, month, date, day (What is the year...?)

2. Name, country, province, city, hospital, floor (Where are we and what county...?)

REGISTRATION:

3. Name 3 objects (I see, for each)

4. Ask patient to repeat all 3.

Score 1 pt. for each right answer at first try. Repeat up to 3 times until all are learned. If after 3 trials they aren't learned, recall cannot be tested.

ATTENTION & CALCULATION:

5. Serial 7s: 100 - 10 = 90 - 10 = 80 - 10 = 70 - 10 = 60

Score 1 pt. for each right answer. Stop at 5.

RECALL:

6. Recall the 3 objects learned above.

Score 1 pt. for each right answer.

LANGUAGE TESTS:

7. Name: PENCIL, WATCH

8. Repeat: "NO FIVE AND TEN DUTTS"

9. Follow a 3 stage command

10. Take the paper in your right hand, fold it in half, and fold it in on the floor.

Read & obey: "CLOSE YOUR EYES"

11. Write a sentence

12. Copy the design

LEVEL OF CONSCIOUSNESS:

Alert _____ Drowsy _____ Stupor _____ Coma _____

Interpretation: _____

0 - 14 _____ Dementia

15 - 23 _____ Depression/cognitive loss

24 - 30 _____ Normal

Save Save and Exit Exit Print

INSTRUCTIONS FOR ADMINISTRATION OF THE MINI-MENTAL STATE

Orientation:

1. Ask for the date, then ask specifically for oriented parts (season, etc.)

2. Ask in turn, "Can you tell me the name of this hospital etc?"

Registration:

Ask the patient if you may test his/her memory. The first repetition determines the score. Repeat up to 3 times until all are learned. If after 3 trials they aren't learned, recall cannot be tested.

Attention & Calculation:

Begin with 100 and count backwards by 7. Stop after 5 subtractions. Or spell "WORLD" backwards. Score is the number of letters in correct order.

Recall:

Ask for the previous three words committed to memory.

Language:

Naming: Show a watch and pencil - name them.

Repetition: Repeat the sentence after you - one trial.

2-Stage command

1 point for each part right.

Reading:

Letters must be large enough. Read it and then do it. 1 point only if he/she closes eyes.

Writing:

Spontaneous: It must have a subject and a verb and be sensible. Correct grammar and punctuation are not necessary.

Copying:

Interesting pentagon with "X" sides are equal. All four angles must be present and 2 must intersect to score 1 point. Ignore any mirror or rotation.

(J. Psychiat. Res., 1975, 12:189-198)



BERG BALANCE SCALE

Balance Item	Score (0-4)
1. Sitting unsupported	_____
2. Change of position: sitting to standing	_____
3. Change of position: standing to sitting	_____
4. Transfer	_____
5. Standing unsupported	_____
6. Standing with eyes closed	_____
7. Standing with feet together	_____
8. Tandem standing	_____
9. Standing on one leg	_____
10. Turning trunk (feet fixed)	_____
11. Retrieving objects from floor	_____
12. Turning 180 degrees	_____
13. Head tilting	_____
14. Reaching forward while standing	_____

TOTAL (0-56): _____

Interpretation

0-10, wheelchair bound

11-16, walking with assistance

17-24, independent

References

Berg K, Wood-Deaghen S, Williams T, Maki B. Measuring balance in the elderly: Validation of an instrument. Can J Phys Ther Occup Therap 1992; 58:1-11.

Berg K, Wood-Deaghen S, Williams T, Maki B. Measuring balance in the elderly: Preliminary development of an instrument. Physiotherapy Canada, 41:304-311, 1998.



Provided by the Internet Stroke Center -- www.strokecenter.org

THE BARTHEL INDEX

Activity	Score
FEEDING:	_____
0 = unable	
1 = needs help cutting, spreading, etc., or requires modified diet	
10 = independent	
BATHING:	_____
0 = dependent	
1 = independent (or in shower)	
DRESSING:	_____
0 = needs help with personal care	
1 = independent (fasten/unfastening implements provided)	
GROOMING:	_____
0 = needs help but can do without help washed	
10 = independent (including brushing, rinsing, etc.)	
WALKING:	_____
0 = needs help to walk to the gross motor	
1 = unaided ambulation	
10 = constant	
CLIMBING:	_____
0 = dependent, or ambulation and unable to manage alone	
1 = unaided ambulation	
10 = constant	
TOILET USE:	_____
0 = dependent	
1 = needs some help, but can do something alone	
10 = independent (in and out, dressing, wiping)	
TRANSFER: (ABLE TO CLIMB, CARRY, BACKS)	_____
0 = unable, no sitting balance	
1 = major help (one or two people, physical aid)	
10 = minor help (verbal or physical)	
15 = independent	
MOBILITY (ON LEVEL SURFACES):	_____
0 = wheelchair or 10 yards	
1 = wheelchair independent, including ramps, > 10 yards	
10 = walks with help of one person (verbal or physical) > 50 yards	
15 = independent (but may use aid, for example, stick) > 50 yards	
STAIRS:	_____
0 = unable	
1 = needs help (verbal, physical, carrying aid)	
10 = independent	

TOTAL (0-100): _____



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Pitfalls of Specific Assessment Measures

- “Measuring outcomes of multidimensional interventions” (Stolee, 2010)
- Reviewed RCTs reviewed in major systematic reviews and meta-analyses of geriatric services
- 56 RCTs



Outcome measures in 52 RCTs

- Physical function measured in 52 studies – 32 measures, 23 significant
- Cognitive function measured in 33 studies – 11 different measures, 6 significant
- Psychosocial function measured in 37 studies -29 measures, 12 significant
- Self-rated health measured in 18 studies – 8 different approaches, 4 significant
- Health care use outcomes measured in 45 studies, 24 significant
- Other outcomes in 32 studies – 16 measures, 13 significant



2nd Generation: Standardized Health Assessments

- One instrument, multiple domains, e.g.:
 - National Rehabilitation Reporting System (inpatient rehab in Canada)
 - OASIS - Outcome an Assessment Information Set (home care in U.S.)
 - interRAI instruments (multiple settings)



3rd Generation: Extend assessment systems across multiple care settings

- A suite of compatible assessment tools
- interRAI consortium (Gray, et al., 2009)



3rd Generation: Benefits (Gray, et al., 2009)

- Reduce assessment effort as patients move across settings
- Consistent recording of information to facilitate interpretation
- Simplified training of assessors
- Administrative advantages (e.g., re software systems)
- Can compare case complexity in different settings



interRAI “Suite” (Gray, et al., 2009)

- Long-Term Care
- Home Care
- Assisted Living
- Acute Care
- Post-Acute Care
- Community Health Settings
- Palliative Care
- Mental Health (inpatient)
- Community Mental Health
- Intellectual Disability



interRAI "Suite" Components (Gray, et al., 2009)

- Clinical assessment information for care planning and decision-making
- Embedded assessment scales [e.g., cognition, depression, activities of daily living (ADL)]
- Clinical assessment protocols (CAPs)
- Quality indicators
- Casemix tools



The MDS/RAI-HC Instrument

Left: The beginning of the form. Right: A more substantive section.

Minimum Data Set Home Care (MDS-HC)® Canadian Version

• Unless otherwise noted, score for last 3 days
• Examples of exceptions include ADLs/Confusion/ Services/Treatments where status scored over last 7 days

SECTION AA: NAME AND IDENTIFICATION INFORMATION

1. NAME OF CLIENT: a. (Last/First Name) b. (First Name) c. (Middle Name/Initial)

2. DATE BIRTH: _____

3a. HEALTH (AND NO.): _____

3b. HEALTH (AND NO.): _____

4. POSTAL CODE: _____

5. PHONE: _____

6. FAX: _____

7. E-MAIL: _____

8. OTHER: _____

9. SEE MDS-HC manual for barcodes/missing codes.

SECTION C: COMMUNICATION/HEARING PATTERNS

1. HEARING: a. HEARS ADEQUATELY—Normal talk, TV, phone, doorbell
b. HEARING DIFFICULTY—Hears not in quiet setting
c. HEARS IN SPECIAL SITUATIONS ONLY—Speaker has to adjust sound quality and speak distinctly
d. HEARLY IMPAIRED—Hearing of unclear hearing
(Expressing information consistent—However able)

2. HEARING SELF UNDERSTOOD: a. UNDERSTOOD—Expresses ideas without difficulty
b. USUALLY UNDERSTOOD—Difficulty finding words or finishing thoughts BUT if given time, little or no prompting required
c. OFTEN UNDERSTOOD—Difficulty finding words or finishing thoughts, prompting usually required
d. SOME TIMES UNDERSTOOD—Ability is limited to making concrete requests
e. RARELY/NEVER UNDERSTOOD

3. ABILITY TO UNDERSTAND OTHERS: a. UNDERSTANDS—Clear comprehension
b. USUALLY UNDERSTANDS—Hears some part/interest of message, BUT comprehends most conversation with little or no prompting
c. OFTEN UNDERSTANDS—Hears some part/interest of message, with prompting can often comprehend conversation
d. SOME TIMES UNDERSTANDS—Responds adequately to simple, direct communication
e. RARELY/NEVER UNDERSTANDS

4. COMMUNICATION: a. INTERFERING IN COMMUNICATION (talking self understood or understanding others) as compared to status of 90 DAYS AGO (or since last assessment if less than 90 days)
b. YES
c. NO
d. I. Yes
e. I. No



On the RADAR for EMR?



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Barriers to Using Health Information in Home Care



Barriers to Using EHIS in Home Care

- Literature review
- Consultation with home care case managers and service providers through workshops and surveys



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LITERATURE REVIEW

- Literature Review
 - The Use of Electronic Health Information Systems in Home Care
 - Top 3 Barriers and Facilitators:

Barriers	Facilitators
Cost (technology, training, maintenance)	PCs / portable technology that allow data to be input at point of care
Training → cost, time commitment, initial loss of productivity	Strategies provided by IT to decrease data entry errors
Staff resistance / lack of user acceptance	Managerial support & user incentives during adoption & early implementation



Consensus Survey

- Survey was administered to 40 different health care providers
- 22 people responded (55% response rate)
 - 86% = Female; 14% = Male
- Occupation
 - 5 Physiotherapists
 - 4 Occupational Therapists
 - 2 Registered Nurses
 - 5 Case Managers/Coordinators
 - 6 Administrative Positions (Directors, Managers, Vice Presidents)



Consensus

- A 70% consensus rate was used for the analysis of the survey responses.
- For responses to be listed as important or prohibitive, 70% of participants needed to indicate a score between 7 – 10 on the Likert scale (option of ranking between 1 – 10).



1. Rate how effective you feel the following modes of communication are in sharing information in home care.

- | | |
|----------------|----------------|
| a) Telephone | Y ¹ |
| b) Fax Machine | N |
| c) Email | N |
| d) Voicemail | N |

2. Rate how important the following processes are for improving information sharing strategies in home care.

- | | |
|--|----------------|
| a) Consistency in the patient information collected | Y ¹ |
| b) Consistency in language/terms used | Y ² |
| c) Consistency in what tools are used to collect patient information | Y ² |
| d) Consistency in procedures used to share patient information | Y ⁴ |



3. Rate how important you feel the following are when sharing patient information with colleagues in home care.

- | | |
|------------------------|----------------|
| a) In-home conferences | Y ¹ |
| b) Team meetings | Y ² |
| c) Peer consults | Y ³ |

4. Rate how important you feel the following factors are in creating a supportive work environment for information sharing.

- | | |
|--|----------------|
| a) Opportunities to engage in continuing education | Y ¹ |
| b) Management support in learning new tools and strategies for providing improved patient care | Y ² |
| c) Culture of individual workplace | Y ³ |



6. Rate how important the following factors are when using EHIS to communicate with other home care service providers.

- | | |
|----------------------------------|----------------|
| a) Easily accessible | Y ¹ |
| b) Interface is easy to navigate | Y ¹ |
| c) Clearly formatted | Y ¹ |
| d) User friendly | Y ⁴ |
| e) Interactive | Y ⁵ |

7. Rate how important you feel the following supports need to be available to users when adopting EHIS in home care.

- | | |
|------------------------------|----------------|
| a) Technical support | Y ¹ |
| b) Training using system | Y ² |
| c) Training using technology | Y ³ |
| d) Booster/update sessions | Y ³ |
| e) Practice guidelines | Y ⁵ |
| f) Online help | Y ⁶ |
| g) Training manuals | Y ⁷ |



8. Rate how important you feel the following factors are when using an EHIS to share information in home care.

- | | |
|--|----------------|
| a) System is collecting correct information | Y ¹ |
| b) System is user friendly/interpretive | Y ² |
| c) System is compatible with other information systems used in the organization | Y ³ |
| d) System can communicate and/or is compatible with IT systems outside organization or with other health care settings | Y ³ |
| e) Strategies are provided to reduce data entry errors | Y ³ |
| f) System is flexible and able to adapt to changes | Y ⁶ |



9. Rate how important the following factors are to adopting EHIS in home care.

a) User participation at the time of development	Y ¹
b) Managerial support	Y ²
c) Cost/benefit analysis	Y ³
d) User incentive during early adoption /implementation	Y ⁴

10. Rate how important the following issues are when using EHIS to collect patient information in home care.

a) Security/patient confidentiality is maintained	Y ¹
b) Maintaining a client centered focus during client interactions	Y ¹
e) Individualized data input allows user to adapt to patient needs	Y ³
d) Data is integrated across encounters with a single patient	Y ⁴
f) Individualized data is focused over aggregate data	Y ⁵

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Implications and Suggestions

- Need supportive work environment
- Create patient documentation (summary abstract?) that is made available to all service providers across settings (But will CCAC share?)
- Supports in place for design, implementation, training, and trouble-shooting
- EHIS and RAI: Need to create awareness of capacity and functions of the inter-RAI → information and training sessions

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Answering Questions Using RAI-HC Data

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A Few Questions

- Does home care rehabilitation (PT or OT) make a difference?
- Who is a good candidate for rehabilitation in home care?
- Who uses rehabilitation in home care?

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Impact of PT/OT on Functional Decline & Improvement in Home Care Clients with MSK disorders:

Statistical Analysis Using Multi-State Markov Models

Data: RAI-HC data for home care clients in Ontario with:

1. MSK disorder (arthritis, osteoporosis, hip fracture or other fractures)
2. At least one "admission" to home care
3. Baseline assessment and at least 2 consecutive assessments
4. A date of death or discharge for each admission

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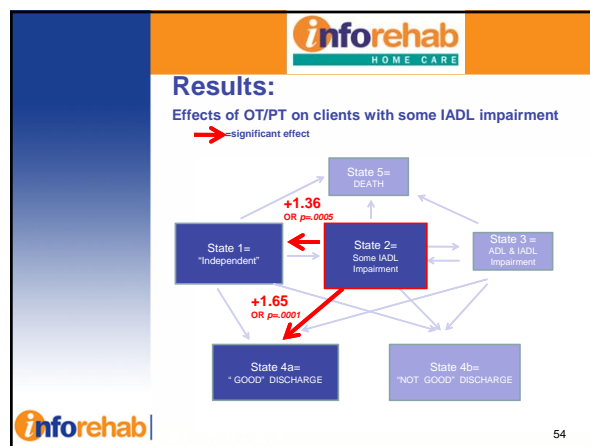
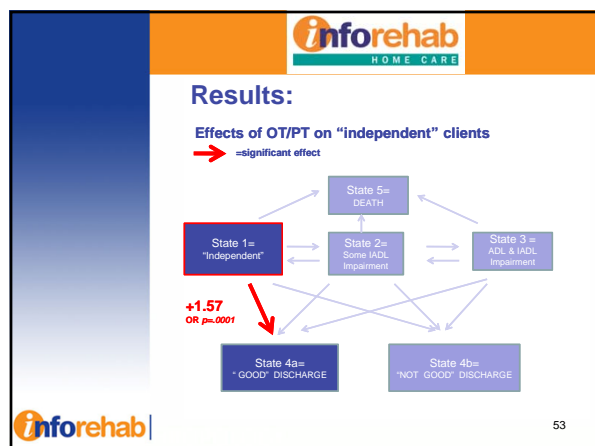
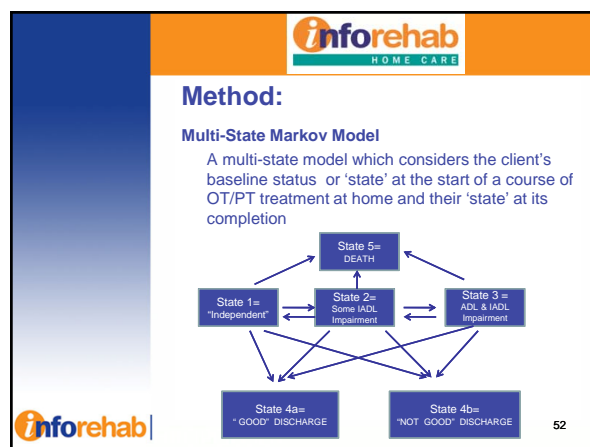
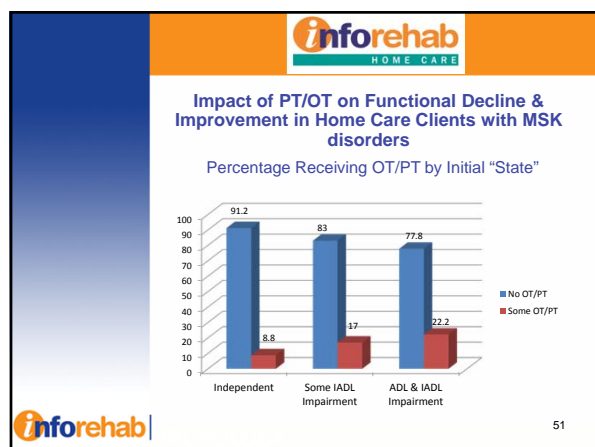
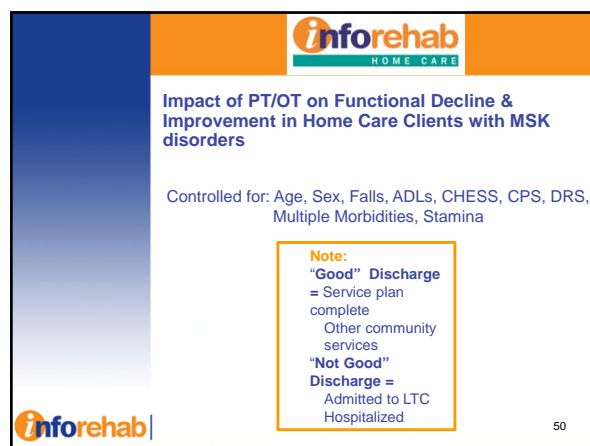
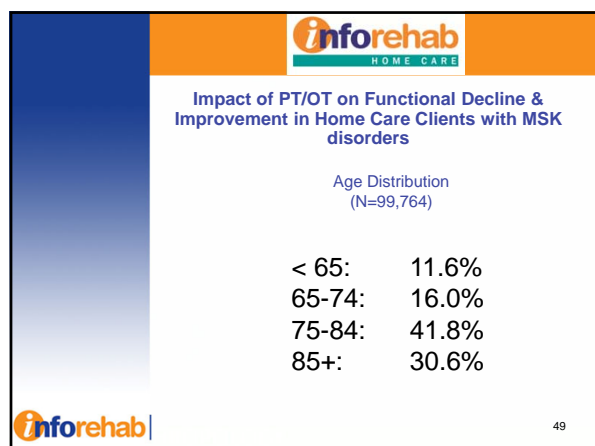
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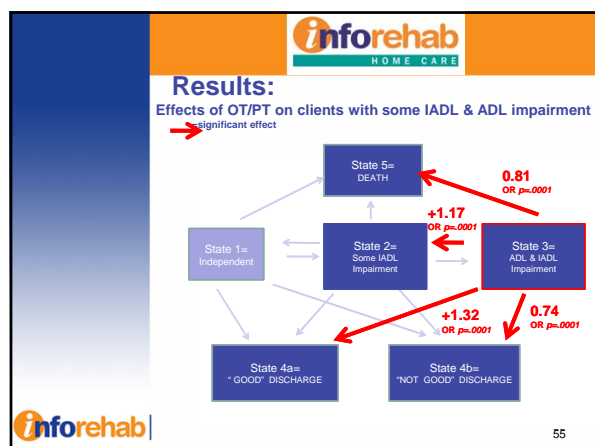
Impact of PT/OT on Functional Decline & Improvement in Home Care Clients with MSK disorders

Number of Patients by Number of Admissions (N=99,764; 74.9% female)

Number of Admissions	Number of Patients
1.	80,012
2.	8,882
3.	830
4.	61
5.	9

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What is the impact of OT/PT on home care clients with MSK disorders?

- Patients who are functionally "independent" (State 1) and who receive rehab are 1.57 times more likely to have a "good discharge"
- Patients with some IADL impairment who receive rehab (State 2) are 1.79 times more likely to be have a "good discharge" and 1.36 times more likely to become more functionally independent
- Patients with both IADL and ADL impairment (State 3) are 1.17 times more likely to improve their functional status, and 1.32 times more likely to have a "good discharge"

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Why is this important?

- Rehabilitation (PT/OT) provided through home care programs, can achieve functional benefits for clients with MSK disorders, and system benefits in terms of successful discharges from home care and reduced LTC admissions
- Many older home care clients (and many older persons generally) who could benefit from rehabilitation do not receive it (77% of clients in this study)
- Resources for home care rehabilitation are being reduced in Ontario
- RAI data can provide evidence of impact otherwise lacking at a system level

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Who is a Good Candidate for Rehabilitation in Home Care: Predicting Rehabilitation Potential

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Machine Learning and Data Mining

Looking for patterns and relationships in large datasets, that provide new knowledge or that may be used to make predictions

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Data: The RAI-HC

Left: The beginning of the form. Right: A more substantive section.

Minimum Data Set Home Care (MDS-HC) Canadian Version

1. Name of client (a) Last/First Name (b) First Name (c) Middle Name/Initial

2. Date of birth (MM/DD/YYYY)

3. Health status (a) Enter the resident's health card number, or enter "W" if unknown or "N" if not applicable (b) Enter the Resident's/Primary code using health card number (c) Enter the Resident's/Primary code using health card number (d) Enter the Resident's/Primary code using health card number

4. Primary code of residence (see MDS-HC manual for homecare/residence codes)

SECTION C. COMMUNICATION/HEARING PATTERNS

1. HEARING (a) HEARS ADEQUATELY—Normal talk, TV, phone, doorbell (b) HEARS DIFFICULTY—Hears but is hard to hear (c) HEARS IN SPECIAL SITUATIONS ONLY—Speaker has to shout and/or use visual aids (d) HEARS IN SITUATIONS ONLY—Speaker has to shout and/or use visual aids

2. HEARING SELF UNDERSTOOD (a) UNDERSTOOD—Expresses ideas without difficulty (b) UNDERSTOOD—Expresses ideas without difficulty (c) UNDERSTOOD—Expresses ideas without difficulty (d) UNDERSTOOD—Expresses ideas without difficulty

3. HEARING SELF UNDERSTOOD (a) UNDERSTOOD—Expresses ideas without difficulty (b) UNDERSTOOD—Expresses ideas without difficulty (c) UNDERSTOOD—Expresses ideas without difficulty (d) UNDERSTOOD—Expresses ideas without difficulty

4. COMMUNICATION (a) COMMUNICATES—Expresses ideas without difficulty (b) COMMUNICATES—Expresses ideas without difficulty (c) COMMUNICATES—Expresses ideas without difficulty (d) COMMUNICATES—Expresses ideas without difficulty

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Predicting Rehabilitation Potential: Candidate Approaches

- ADLCAP
 - current Clinical Assessment Protocol used to assess rehabilitation potential
- K-Nearest Neighbours Algorithm (KNN)



Home Care Clients

- Eight (8) Community Care Access Centres (CCACs) in Ontario
- 24,724 long-stay home care clients:

Mean Age: 76.3 (SD 13.9)

68.9% Female

15.7% Alzheimer disease or other dementia



Definition of Rehabilitation Potential for Validation Purposes

- improvement in ADL functioning over a follow-up period of about 12 months;

OR

- discharge disposition to home.



ADLCAP

- Predicts rehabilitation potential based on combination of variables:
 - Activities of daily living, ability to understand others, health stability, and ratings of functional potential
- Same variables used in KNN algorithm



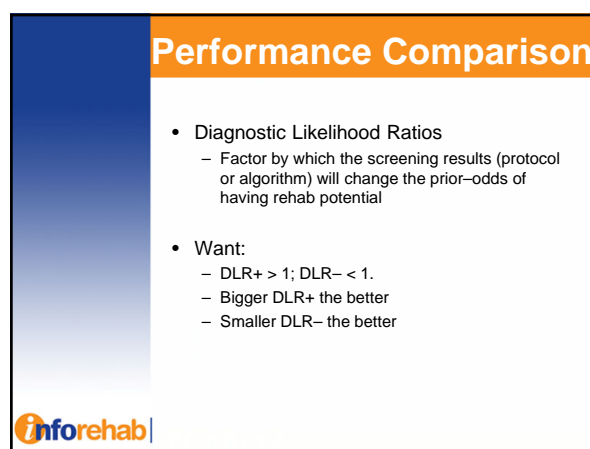
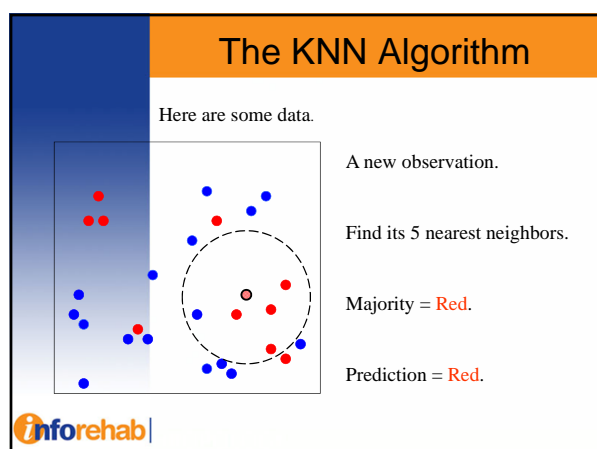
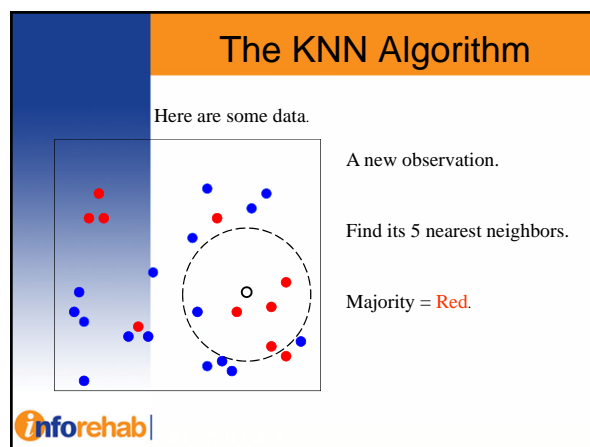
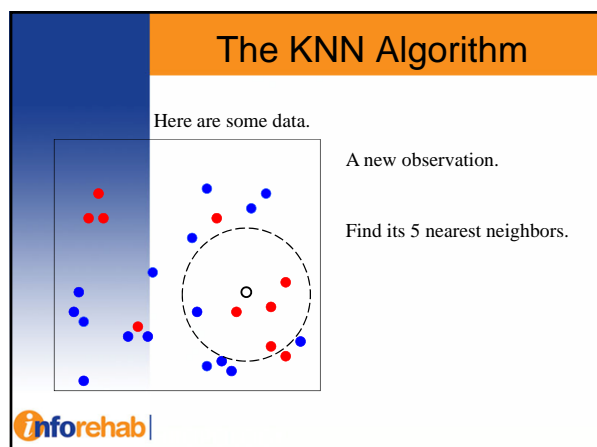
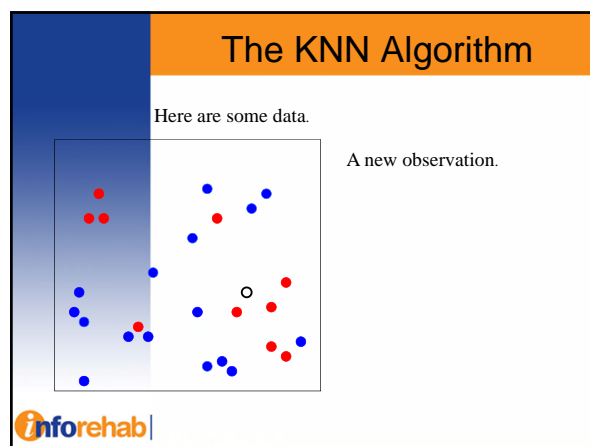
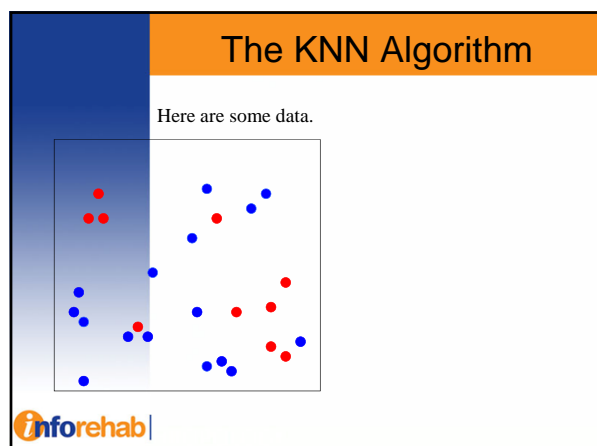
ADLCAP: SAS CODE

```
if h2a in (2,3,4,5,6,8) then adl1=1; else adl1=0;
if h2b in (2,3,4,5,6,8) then adl2=1; else adl2=0;
if h2c in (2,3,4,5,6,8) then adl3=1; else adl3=0;
...
adlnum=sum(of adl1-adl10);
if (adlnum ge 2) AND (c3 in (0,1,2)) AND
  (p6=2 OR h3=1 OR k8b=1 OR k8c=1 OR k8d=1 OR h7a=1
   OR h7b=1 OR h7c=1)
then adlcap=1; else adlcap=0;
```




K-Nearest Neighbours Algorithm





KNN Comparative Results: DLR				
Region	DLR+		DLR-	
	CAP	KNN	CAP	KNN
1	1.1841	1.8826	0.9227	0.5484
2	1.2442	2.0088	0.8911	0.5537
3	1.1431	1.8415	0.9323	0.6835
4	0.9944	2.1511	1.0031	0.5040
5	1.2479	2.5704	0.9103	0.6452
6	1.0062	2.4049	0.9963	0.5470
7	0.9521	2.2882	1.0363	0.5080
8	1.0311	2.0775	0.9815	0.5844
Mean	1.10	2.15	0.96	0.57

KNN
<ul style="list-style-type: none"> • More informative than ADL CAP • Main limitations: <ul style="list-style-type: none"> • Need to store entire database in memory • Lack of interpretability.



Identifying Heterogeneity in the Home Health Care System of Ontario:
A K means clustering Analysis of Rehabilitation Service Users

Authors: Joshua J. Armstrong, Mu Zhu, John Hirdes, Paul Stolee

The home health care system in Ontario provides a variety of services to a large number of individuals throughout the province.

Researchers and policy makers have long recognized that home care populations are heterogeneous yet little research has focused on this phenomenon.

OBJECTIVE

As part of the iinfo rehab project, this study examines:

How home care clients that utilize rehabilitation services cluster together based upon a range of clinical factors

Overall Objective: To develop rehabilitation client profiles.

CLUSTERING TECHNIQUE

To accomplish our objective, we employed a machine learning technique known as K-means clustering

K Means Clustering

- Exploratory data mining technique
- Works well in large datasets
- Unsupervised learning
- Used to group cases together on the basis of patterns of similarity

DATA

- Utilized RAI-HC Assessment data
- Examined clients who received rehabilitation services (OT or PT) within the first 3 months of the assessment
- 150, 253 clients

Female: 66.7%	Average Age: 76.8
Arthritis: 55.4%	Osteoporosis: 23.6%
Experience Daily Pain: 60.8%	Hip Fracture: 5.6%
CHESS >= 2: 12.2%	Live Alone: 35.1%

VARIABLES

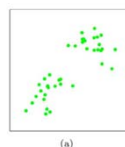
Once we created the rehabilitation client dataset, the next step was to choose the variables to be included in the cluster analysis

- The selection process was assisted by consultation with InfoRehab's quantitative statistical research team and SAS variable selection techniques (Proc Varclus)
- Variables need to be relevant to rehabilitation clients
- 37 variables were chosen for the analyses**

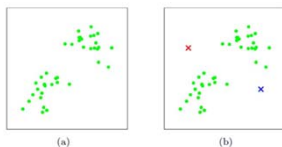
K-MEANS CLUSTERING

K-means clustering is a popular partitive clustering algorithm that was chosen due to its ability to reach convergence on a solution in large data sets in a short amount of time.

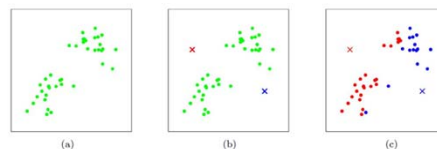
The following is an simplified, two dimensional illustration of how the algorithm works...



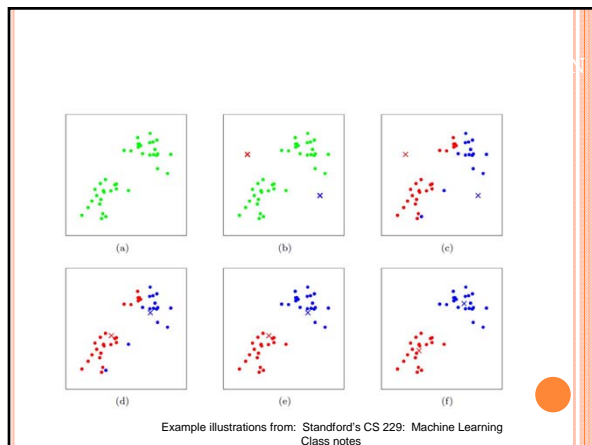
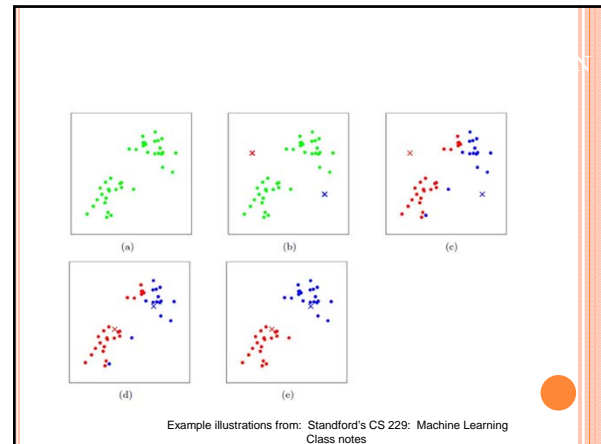
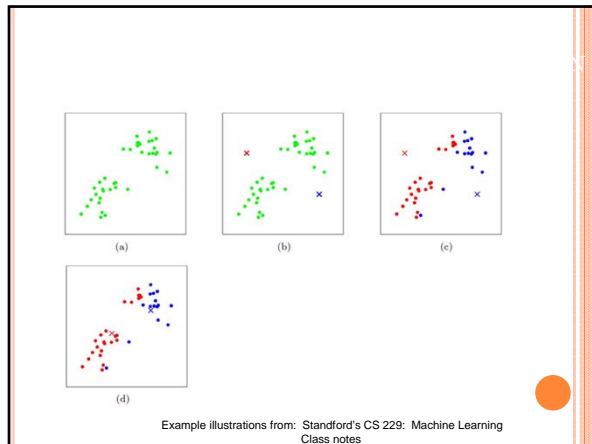
Example illustrations from: Stanford's CS 229: Machine Learning Class notes



Example illustrations from: Stanford's CS 229: Machine Learning Class notes



Example illustrations from: Stanford's CS 229: Machine Learning Class notes



K MEANS

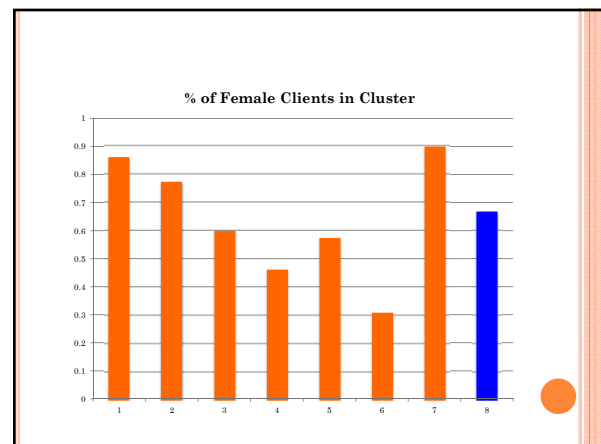
One drawback of the k-means clustering algorithm is that the k (number of clusters) has to be determined.

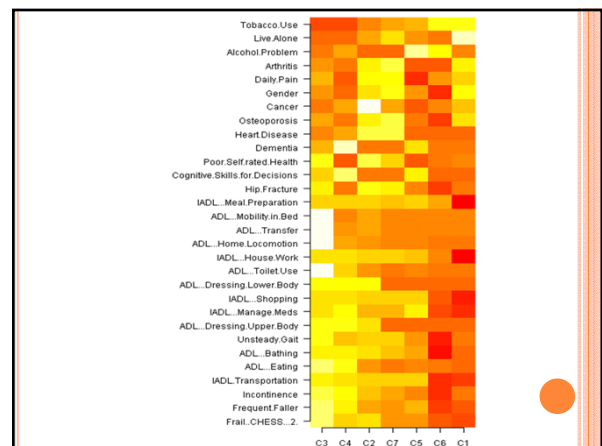
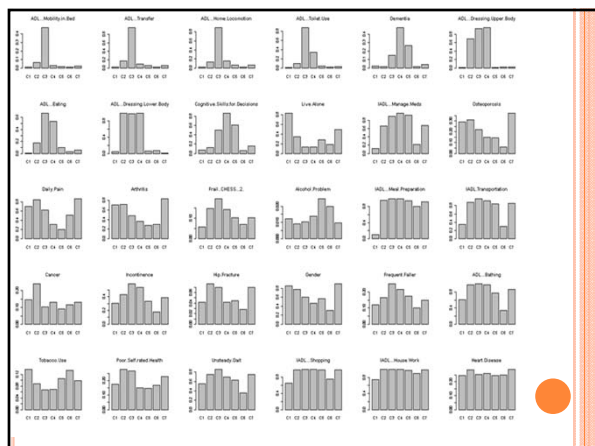
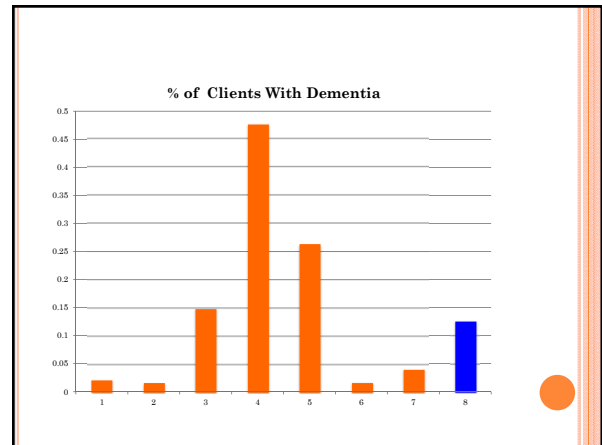
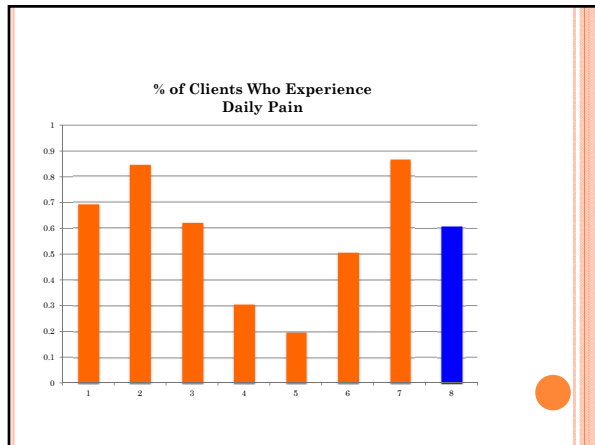
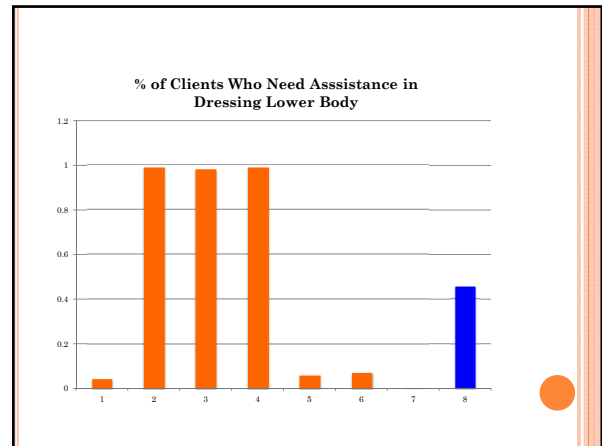
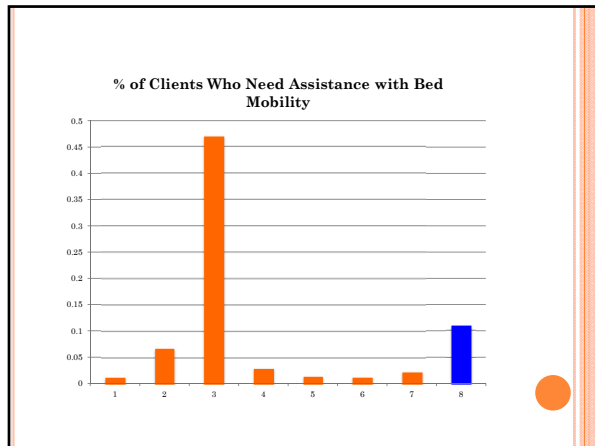
After looking at the range of possible solutions through the lens of the 3 statistical criteria (Pseudo F, Cubic Clustering Criterion, and the Squared Multiple Correlation), we chose a:

7 cluster solution

K-MEANS CLUSTER SOLUTION

- The k-means algorithm labels each individual client with their cluster membership.
- We can then look at the RAI-HC data, calculate means of each of the clusters, and graph the variables in order to assist in determining profiles
- In the next series of graphs, 7 clusters are graphed in yellow and the 8th blue column is the overall average of the entire sample.





NEXT STEP: CREATE PROFILES

The next step in the process is to generate unique cluster descriptions using the graphs and cluster averages of the numerous RAI-HC variables.

In other words, we create seven client profiles using the clusters formulated by the k-means algorithm.

RESULTS

Cluster 1: Older Females who live alone and needs assistance with housework and bathing

- 10% of Rehab Clients
- 86% Female
- 83% Live Alone
- Average age 76.4
- 70% have arthritis
- 29% have osteoporosis
- Majority need help with:
 - housework (75%)
 - bathing (61%)
- Few with cognitive problems

Cluster 2: Older Females, Needs Assistance with IADLs and some ADLs

- 14% of Rehab Clients
- 77% female
- Average Age of 76.5
- Needs assistance with:
 - meal preparation (95%),
 - housework (100%),
 - managing their medications (67%),
 - shopping (99%),
 - transportation (87%),
 - dressing their upper body (70%),
 - dressing their lower body (99%),
 - bathing (97%).

RESULTS

Cluster 3: Frail Elderly, Cognitive Problems, Extremely Dependent and Immobile

- 9% of Rehab Clients
- Highly dependent across all ADL and IADL domains
- Average age of 76.3 years
- 20 % had a 2 or higher on the CHES scale
- 15% with dementia
- 27% with a stroke

Cluster 4: Cognitively Impaired, Dependent but Mobile Elderly

- Largest cluster (23%)
- Average age 78.9 years
- 48% with dementia
- 86% had problems with daily decision making
- Similar to cluster 3 in many ways with the exception of mobility
- Highly Dependent

RESULTS

Cluster 5: Elderly Needing Assistance with IADLs and Bathing

- Average age 78.2
- Relatively independent in their ADLs with the exception of bathing
- Majority require assistance with all IADL domains
- 26% with dementia
- 61% was assessed with problems with their daily decision making

Cluster 6 (10%): Younger Impaired Males, Need Assistance with Meals, Housework, and Shopping

- Youngest of all clusters (70.6 years on average)
- Primarily male (69%)
- High proportion of smokers (13%)
- Need assistance with meal preparation, housework and shopping

Cluster 7 (15%): Functioning Elderly Females, Need Assistance with IADLs

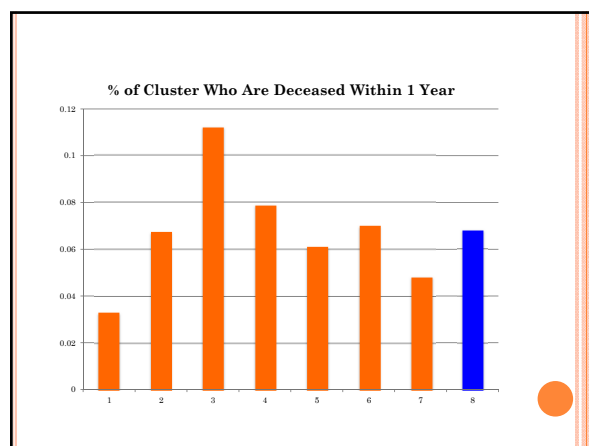
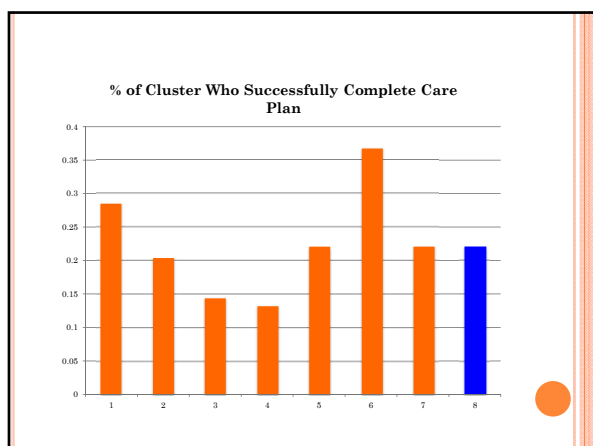
- Primarily female (89%)
- Majority of this cluster need assistance with their IADLs
- Highest rate of osteoporosis (37%) and arthritis (86%)

Discussion

- With the drastically increasing amount of available health data, cluster analysis can play a role by elucidating the naturally forming clusters or groups within the population
- Limited health service resources means that we need to increase our understanding of the population and how we can efficiently improve their care

DISCUSSION

- The 7 clusters differed in numerous meaningful ways:
 - Differing ability to carry out activities of daily living and instrumental activities of daily living
 - Differing patterns of disease, gender, home living status, cognitive ability
- This cluster solution requires further validation, however, preliminary work looking into outcomes (1 year after assessment) demonstrates significant differences in outcomes



DISCUSSION

- These results satisfied our objective of creating profiles, however, this clustering technique can be used in more of an applied fashion
- Heterogeneity can be further uncovered by focusing on specific domains (i.e., patterns in service use; types of PT clients)
- This type of information can be used to better plan services and programming for the expanding population of older adults

Take Home Points

- Vast heterogeneity exists in rehab client population, and this shouldn't be neglected when planning/assessing/researching
- Due to limited resources means, we need to improve our understanding of the population and how we can help them
- The results point to the utility of cluster analysis as a mechanism to organize and identify patterns within the rich array of information provided by RAI assessment tools

MORE TAKE HOME POINTS

- Potential role for data mining and other alternative algorithms in prediction and clinical decision-making
- Interpretability of results a challenge - Would clinicians accept a "Black Box" approach?
- Data mining algorithms may "set the bar" for conventional approaches



RAI-HC data:

- Census-level data on long-stay home care clients, including:
 - Service use (PT/OT)
 - Comprehensive client data to permit adjustment for important client characteristics/covariates
 - Multiple long-term follow-ups
 - Functional outcome data
 - Discharge disposition (through linkage to administrative data)

803

ANOTHER TAKE HOME POINT

- Standardized health assessment systems provide a wealth of valuable data for care planning, resource allocation, quality improvement, and research
- But you've got to actually use the data.

Thank You

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A Cautionary Tale: The Story of P2J

At first, P2J (medication by injection) was found to be the most important predictor, highly predictive of receiving rehab.

Deeply puzzled, we investigated.

Turned out there was an error in the original data sets: P2J appeared to be an identical copy of P2P (receipt of PT within last 7 days).



Thanks Again

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ADLCAP

- The client has rehabilitation potential if he or she:
 - Needs supervision or greater assistance in at least 2 activities of daily living, AND
 - Has the ability to understand others, AND
 - Any of the following are present:
 - Care needs have increased in past 90 days, OR
 - ADL status has declined in past 90 day, OR
 - Health condition unstable, OR
 - Flare-up of recurrent or chronic problem, OR
 - Treatment change in last 30 days because of a new acute episode or condition, OR
 - Client OR Caregiver believes client is capable of increased functional independence, OR
 - Good prospects of recovery.