The ageing crisis in health care: are there enough old people to go around?

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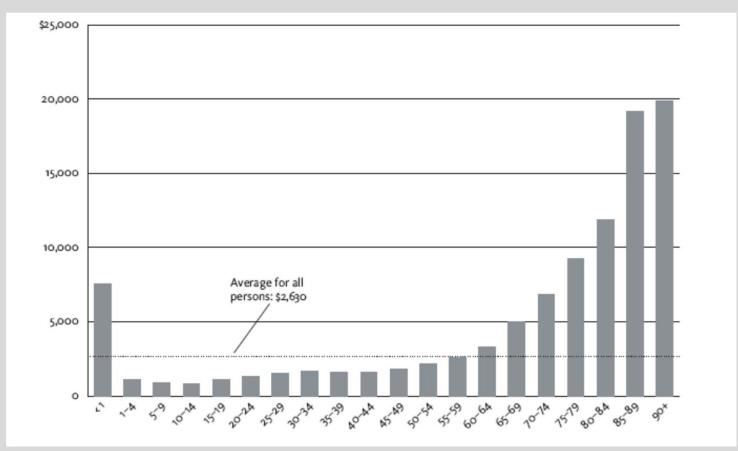
Disclosures

- My disclosures in 2011-2013 noted applications to various Canadian government schemes to commercialize a version of the frailty index based on a comprehensive geriatric assessment, but no longer.
- We asserted copyright of the Clinical Frailty Scale, and ask users not to change or commercialize it.
- Key methodological papers are published in the open access literature, incl. BMC Geriatrics and (for animal work) J Gerontol Biol Sci.



Expenditures Per Capita By Age Group

Figure 1





How sustainable is Medicare? The Canadian Centre for Policy Alternatives - 2012

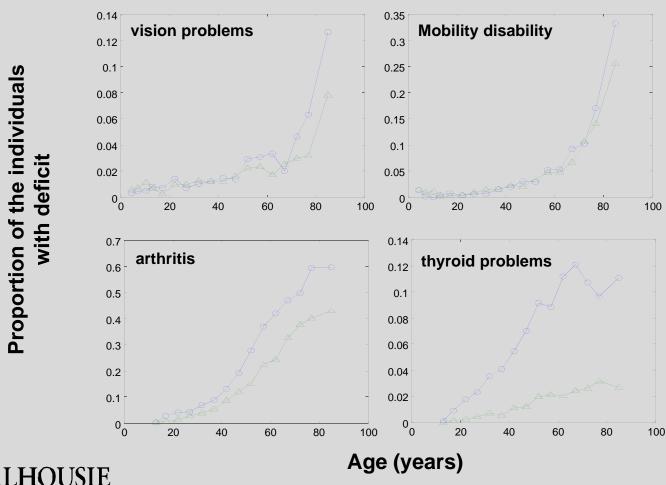
Goals

- 1. To outline how frailty relates to ageing.
- 2. To outline how frailty challenges modern health care.
- 3. To suggest how we might better meet those challenges.



Frailty as deficit accumulation: with age, most problems become more common

(Canadian National Population Health Survey, n= 66,580)





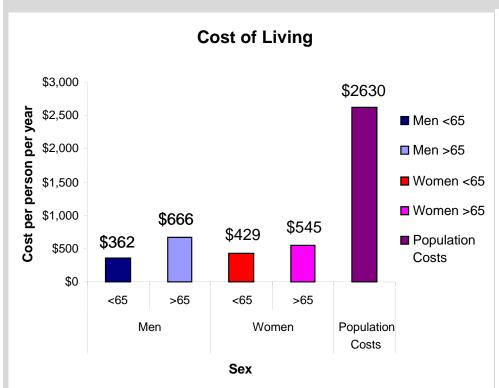
Rockwood & Mitnitski Rev Clin Gerontol 2007;18:1-12.

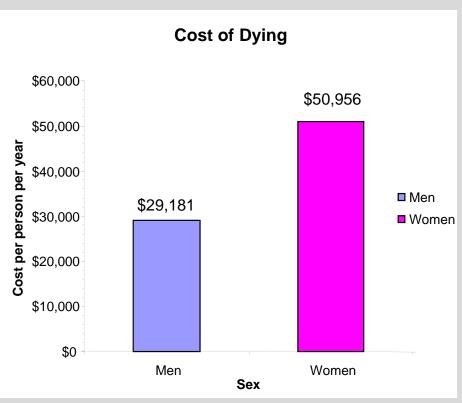
Consider this formula

- Condition X is common (ish).
- Condition X is associated with age.
- As the population ages, condition X will become even more important.
- We must invest in better care/resources/ technology/interventions/training for condition X.



Cost of Living *vs* Cost of Dying – exclude LYOL







People age at different rates.



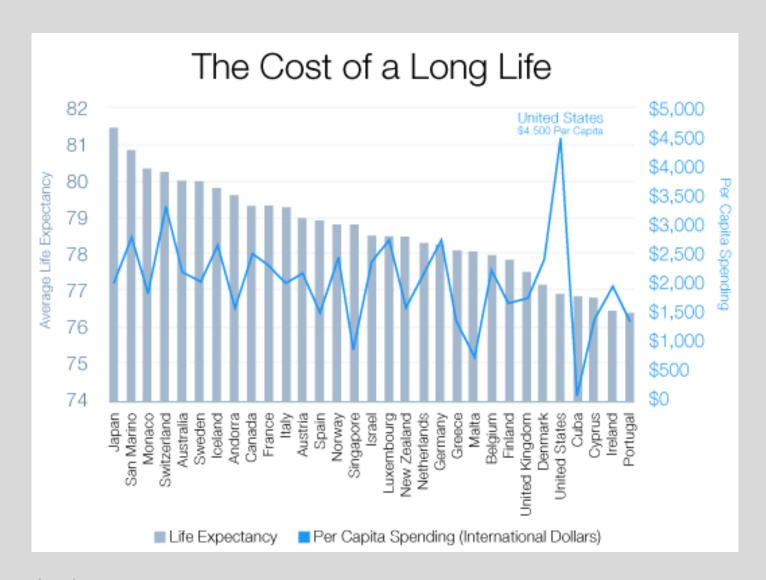




Why does this matter?

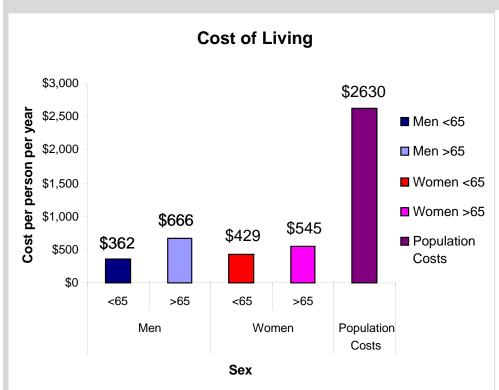
Because frailty changes care needs, and challenges how modern medical care is organized.

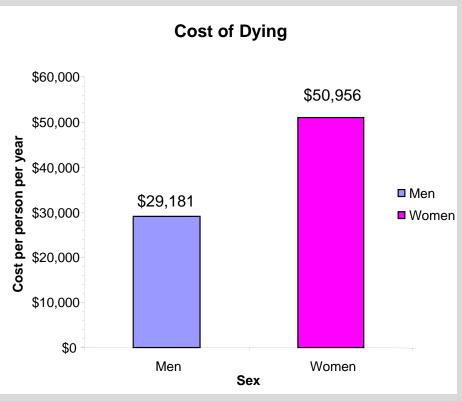






Cost of Living vs Cost of Dying – exclude LYOL







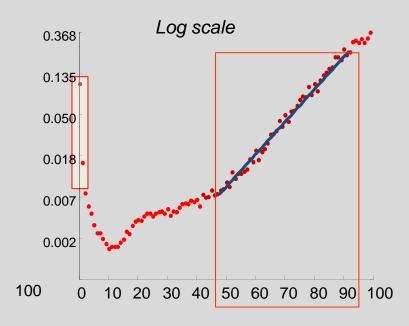
The argument in brief (1)

- 1. Ageing occurs via the subcellular accumulation of deficits, which scale up to represent disease.
- 2. Frailty represents accelerated accumulation of health deficits, making some people more vulnerable than others of the same age.
- 3. When someone is frail, they are best thought of as a complex system close to failure, and not as a person with multiple diseases.



Chronological age is a common measure of the ageing process

 $\mu = R \cdot \exp(\alpha \cdot t)$



Age (years)

The rate of mortality as a function of chronological age. (Canadian data, cohort 1900-1901).



The frailty index

Frailty Index =

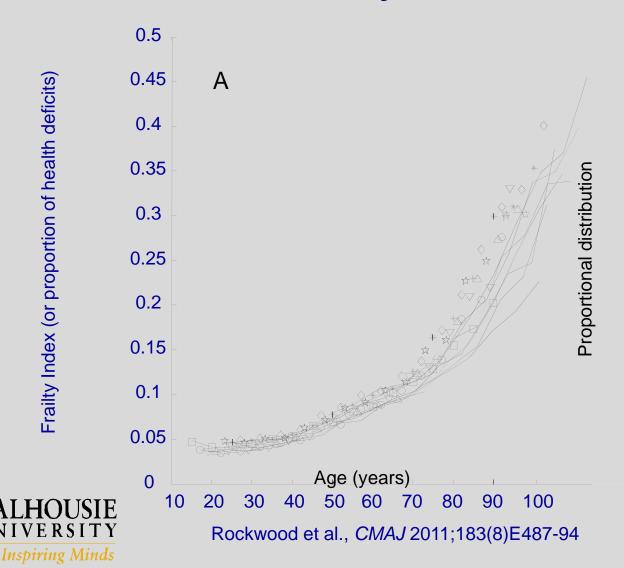
Number of deficits in an individual

Total number of deficits measured

e.g. in a dataset with 50 health deficits measured, a person with 10 things wrong (10 deficits) has a frailty index of 10/50 = 0.20.



Deficits accumulate characteristically at all adult ages



National
Population
Health Survey Mean Frailty
Index at each
cycle in relation
to age

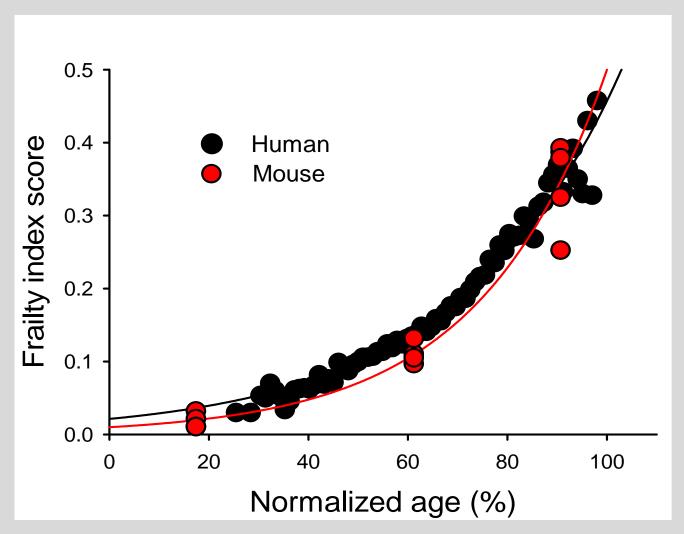
Case subject



Fit comparator



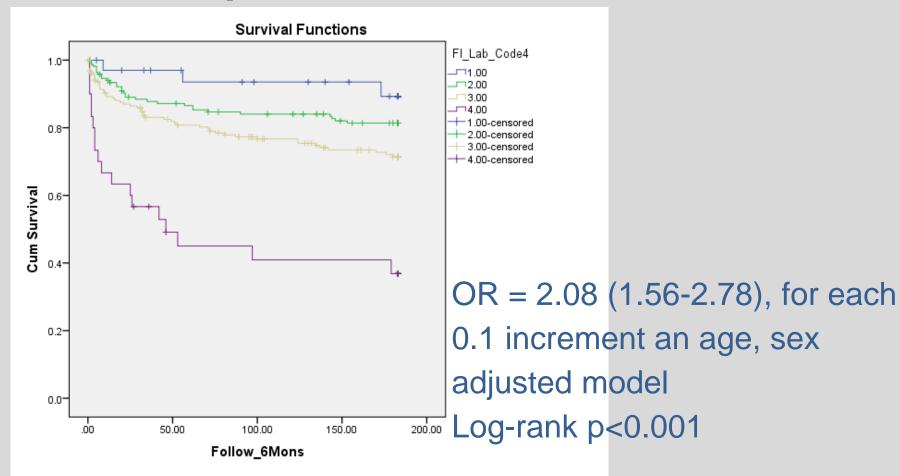






Whitehead et al., *J Gerontol A Biol Sci Med Sci* 2014;69(6):621-632.

Six-month survival by FI-lab scores, in 427 older ED patients consulted to Medicine





At any age, women accumulate more deficits than do men. For men & women, deficit accumulation is highly correlated (r>0.95) with mortality

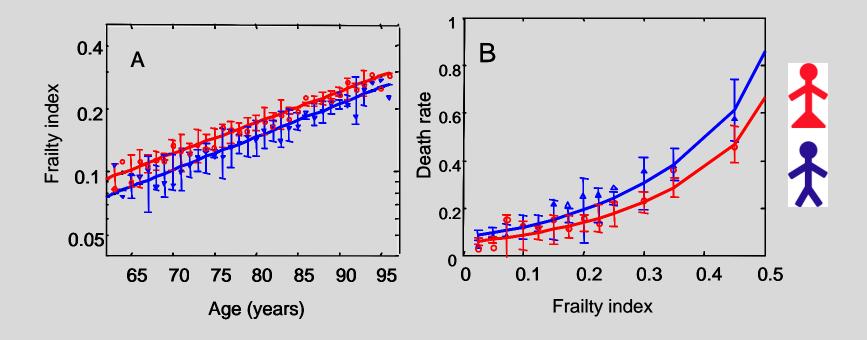




Table 1. List of deficits used in the frailty index.

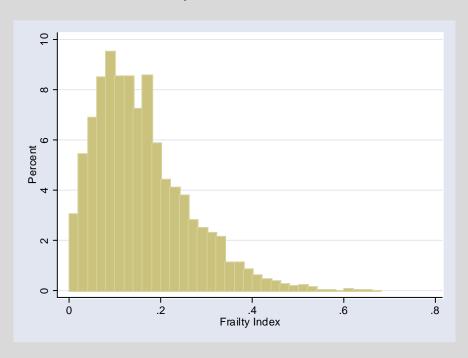
Deficits

Levels

1	Eyesight	5
2	Hearing	5
3	Help to eat	3
4	Help to dress	3
5	Ability to take care of appearance	3
6	Help to walk	3
7	Help to get in and out of bed	3
8	Help to go to the bathroom	3
9	Help to take a bath or shower	3
10	Help to use the telephone	3
11	Help to travel beyond walking distance	3
12	Help with shopping	3
13	Help to prepare own meals	3
14	Help to do housework	3
15	Ability to take medications	3
16	Ability to handle own money	3
17	Self-rated health	5
18	Troubles prevent normal activities	3
19	Lives alone	2
20	Having a cough	2
21	Feeling tired	2
22	Nose stuffed up or sneezing	2
23	High blood pressure	2
24	Heart and circulation problems	2
25	Stroke or effects of stroke	2
26	Arthritis or rheumatism	2
27	Parkinson's disease	2
28	Eye trouble	2
29	Ear trouble	2
30	Dental problems	2
31	Chest problems	2
32	Trouble with stomach	2
33	Kidney trouble	2
34	Losing control of bladder	2
35	Losing control of bowels	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
36	Diabetes	2
37	Trouble with feet or ankles	2
38	Skin problems	2
39	Fractures	2 2
40	Trouble with nerves	2

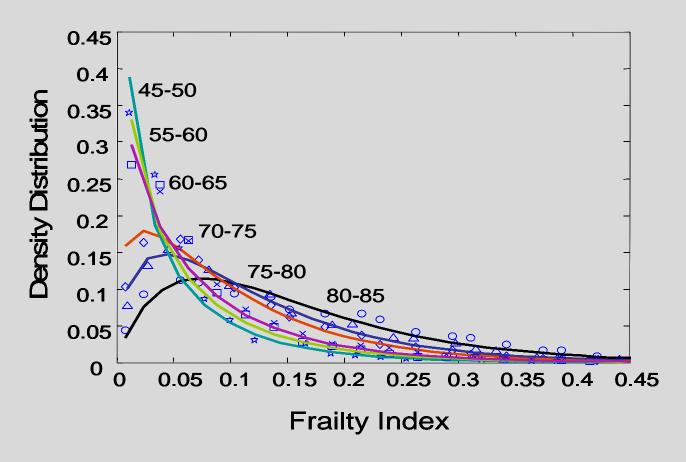
Measuring frailty as an index of (40) deficits

Frailty index distribution



Range = 0 to 0.66, mean 0.16
 The higher the Frailty Index, the more frail the individual

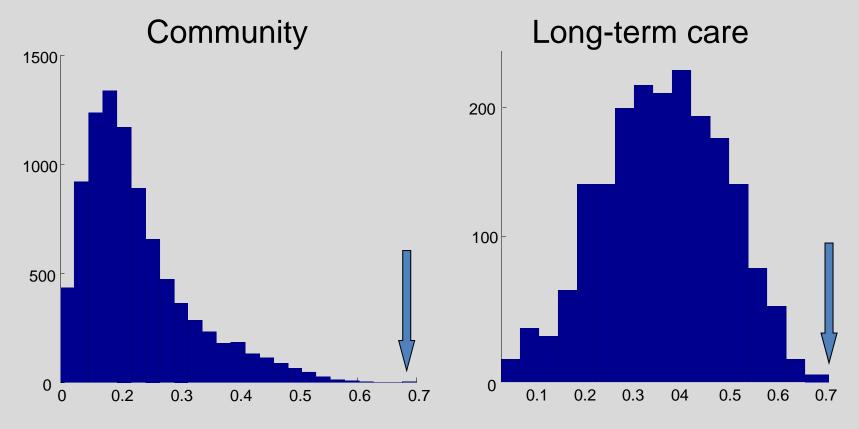
The shape of the distribution changes with age, but is bounded, including by an upper less than the theoretical maximal value of 1.0.



The distribution changes from very skewed at 45-50 years to more symmetrical at old ages



The Frailty Index distribution is typical and consistent and does not have a ceiling effect



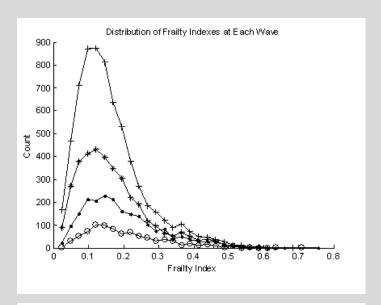
Frailty Index

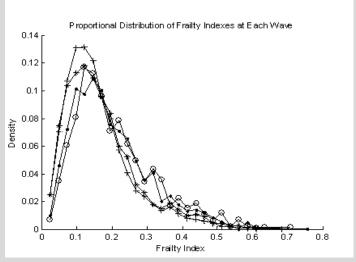


Distribution of the Frailty Index

in 4 successive waves of the Chinese Longitudinal Health and Longevity Study;

Subjects aged 80-99 years; n= 6664



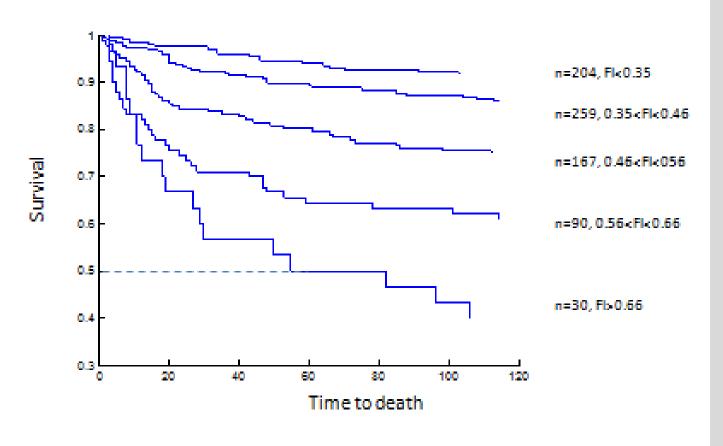




Bennett S, et al., A limit to frailty in very old, community-dwelling people: A secondary analysis of the Chinese Longitudinal Health and Longevity Study. *Age and Ageing*. 2013;42:372-377.



Kaplan-Meier Survival by the strata of the FI

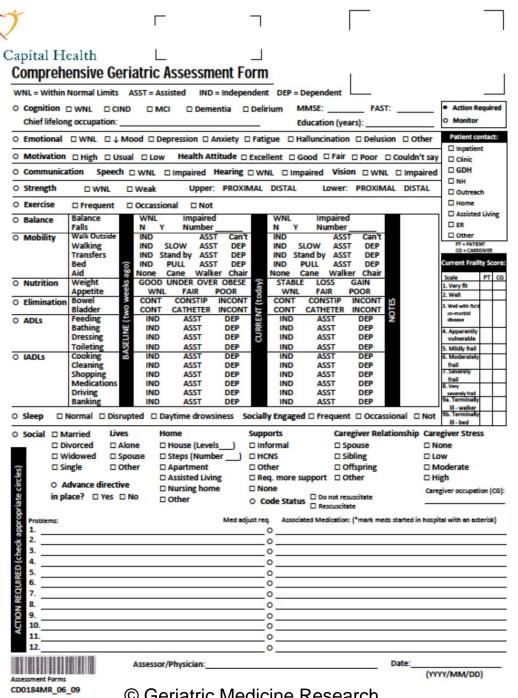




Evans et al., *Age Ageing* 2014;43(1):127-132.

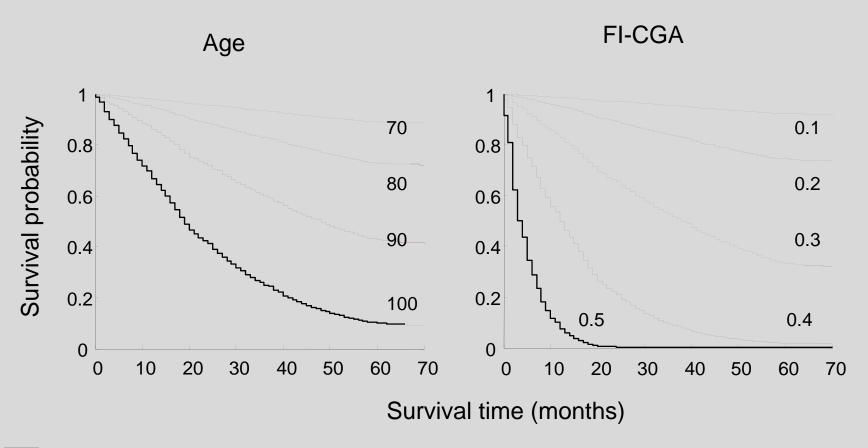
Comprehensive Geriatric **Assessment Form**





© Geriatric Medicine Research

A frailty index based on a Comprehensive Geriatric Assessment (FI-CGA) better stratifies 70-month survival than does age

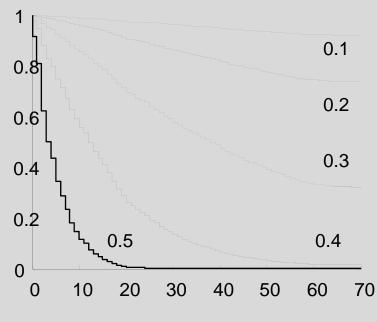


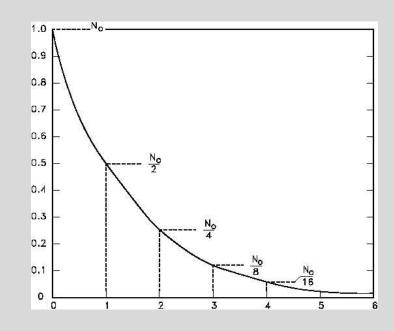


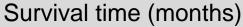
A Frailty Index based on a Comprehensive Geriatric Assessment identifies a group at the highest risk of dying (some of whom live 18 months).

FI-CGA



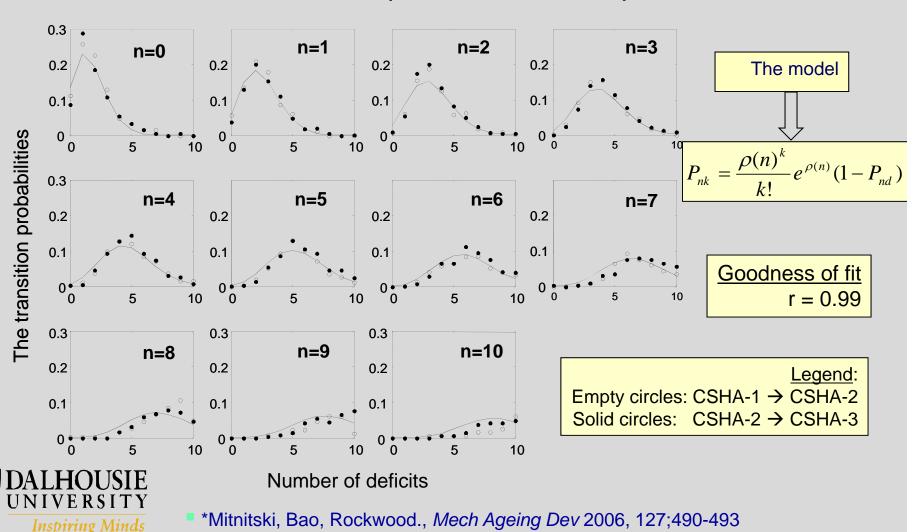




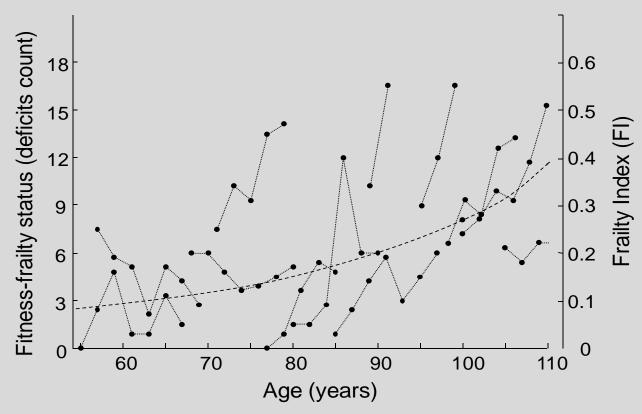




5-year transitions between different states of health (empty circles), replicated 5 years later (solid circles)*



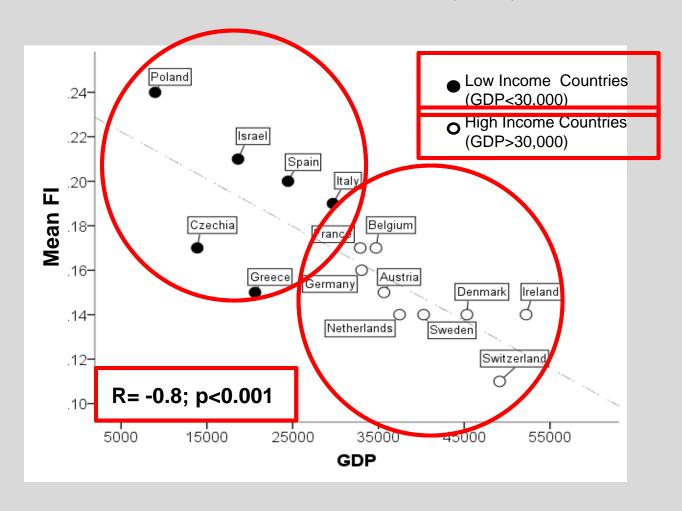
Individuals show many trajectories in accumulation health deficits





Frailty and National Income

Mean FI and Gross Domestic Product (GDP)





Current Outcomes of Acute Care





The argument in brief (1)

- 1. Ageing occurs via the subcellular accumulation of deficits, which scale up to represent disease.
- 2. Frailty represents accelerated accumulation of health deficits, making some people more vulnerable than others of the same age.
- 3. When someone is frail, they are best thought of as a complex system close to failure, and not as a person with multiple diseases.



The argument in brief (2)

- 4. Frail older adults challenge health care systems, by the complexity of their having many, interacting health and social problems.
- 5. Health care has benefitted greatly from subspecialization. People with one thing wrong still do.
- 6. For the frail older patient that time has passed; we must innovate to address their needs.
- (The orderly behaviour of the frailty index offers a means of bridging basic science & clinical studies.)



Acknowledgments

Funding sources:

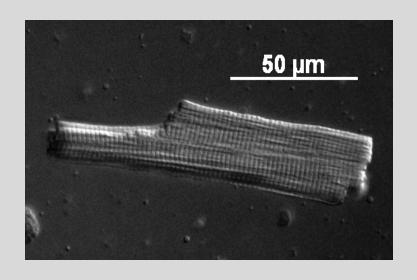
- Fountain Innovation Fund of the QEII Health Sciences Foundation
- Canadian Institutes of Health Research
- Mathematics of Information Technology and Computer Science program, National Research Council
- Alzheimer Society of Canada
- National Natural Science Foundation of China
- Dalhousie Medical Research Foundation

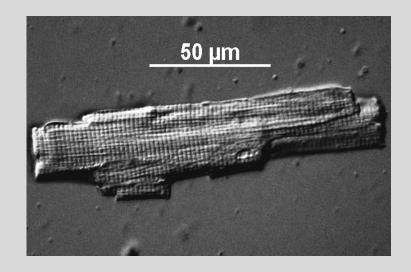
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- Fernando Pena
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- Melissa Andrew
- Judah Goldstein
- Michael Rockwood
- Samuel Searle
- Susan Kirkland



Cardiomyocyte hypertrophy



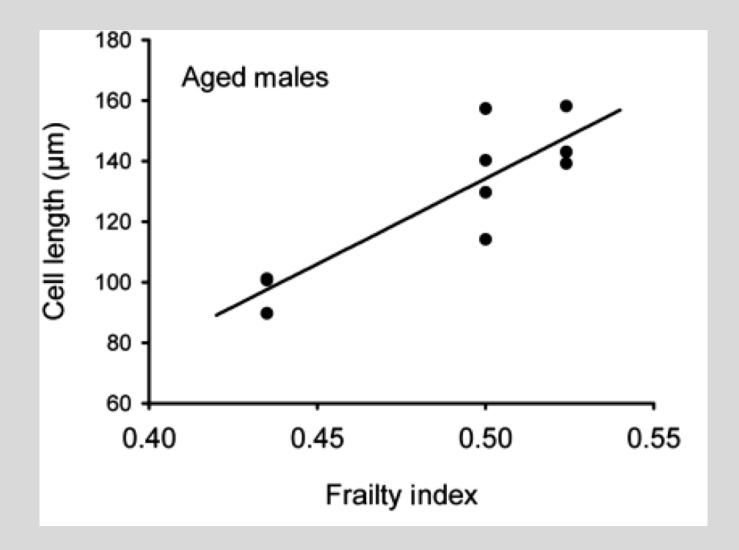


Young adult mice & rats (3-6 mos)

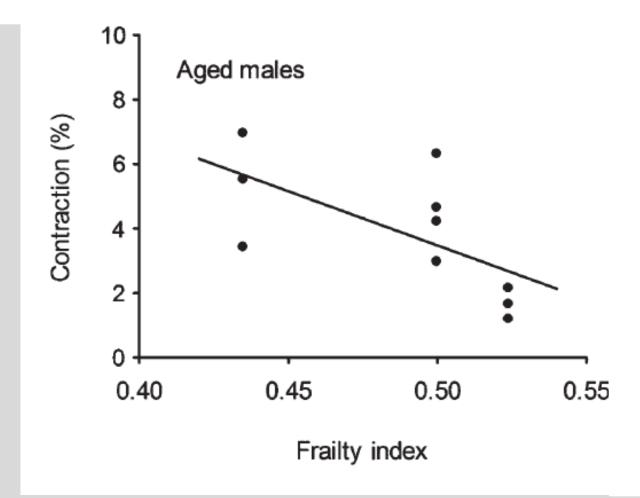
Aged mice & rats (24 mos)



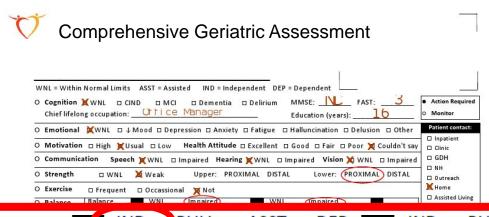
Howlett *Am J Physiol 298*:H659-70, 2010 Grandy & Howlett Am J Physiol, 291: H2362-2370, 2006











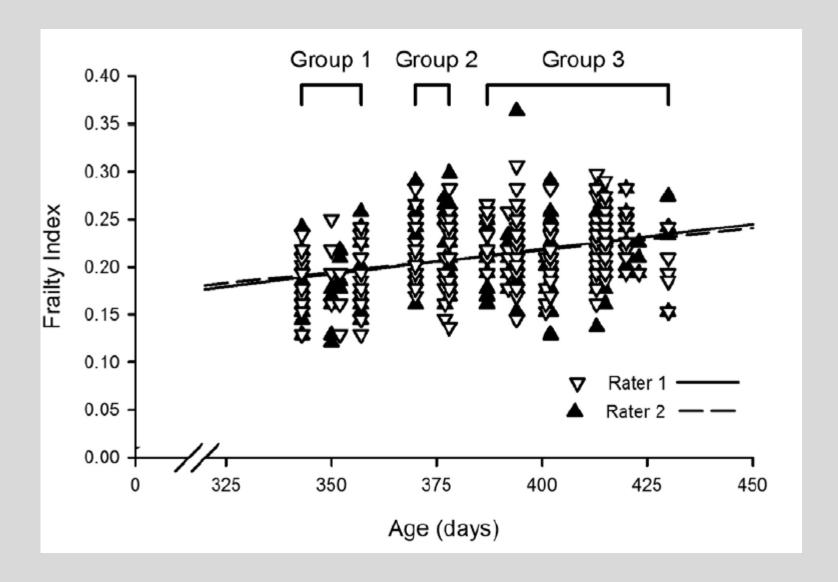
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Proble		Med adju		Associated Medication: (*mark meds started	in nospital with an asteriski						
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2.	COPD	13.56	0	Advir/Ventolin +/- Prednise	one						
3.	Osteoart	hritis	0	Tylenol PRN (no NSAIDs)							
4.	Osteopor	osis	0	-							
5.	Mild CRF		0	Ramipril 5 mg/day							
6.	Disordere	ed sleep	_ 0	Trazadone 50 mg PO qhs							
7.	Hyperten	sion	_ 0	Amlodipin 5 mg							
8.	GERD		_ 0	Omeprazol 20 mg/day							
9.	Large lui	ng mass (XR NYD)	_ 。								
10.		ngb 85(N) indices	- 0	2							
11.	Hyponati	remia Nat = 128	_ 0								
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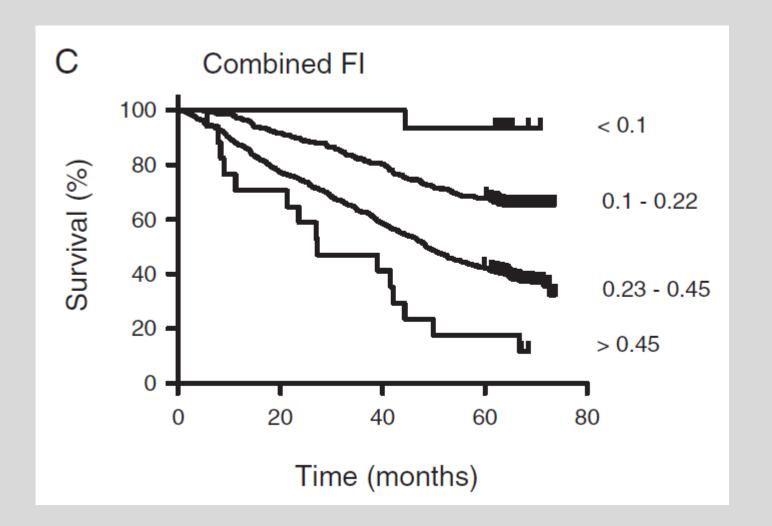
TABLE 1: 1	Mouse Frail	ty Assess	ment Forn	n				
			Date	e:				
Mouse #: Body weight (g)	Date of Birt Surface bod	y tempera	–	Sex: F M				
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Gait Tremor Forelimb grip strength Body condition score Vestibulocochlear/Auditory: Head tilt Hearing loss Ocular/Nasal: Cataracts Discharge/swollen/ squinti Microphthalmia Corneal opacity		Phy	*	Tumou Distend	c uloskeletal syste r rs led abdomen is/hunched posture	0 0	0.5 0.5 0.5	1 1 1
Vision loss Menace reflex Nasal discharge Digestive/Urogenital system: Malocclusions	0 0.5 0 0.5 0 0.5	1 1 1						
 Rectal prolapse Penile/uterine prolapse Diarrhoea Respiratory: 	0 0.5 0 0.5 0 0.5	1 1 1						
Breathing rate/depth Discomfort: Mouse Grimace Scale Piloerection	0 0.5 0 0.5 0 0.5	1 1 1						
Temperature score: Body weight score: Total Score/ Max Score:								





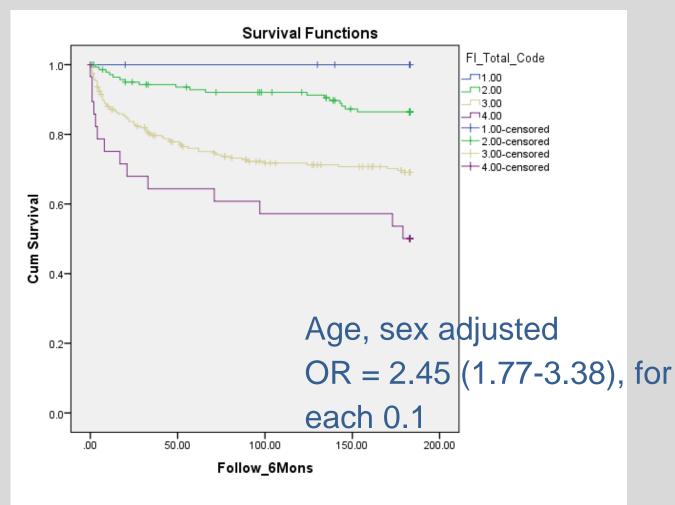


Feridooni et al., *J Gerontol A Biol Sci Med Sci*. 2014 Sep 9. pii: glu161..

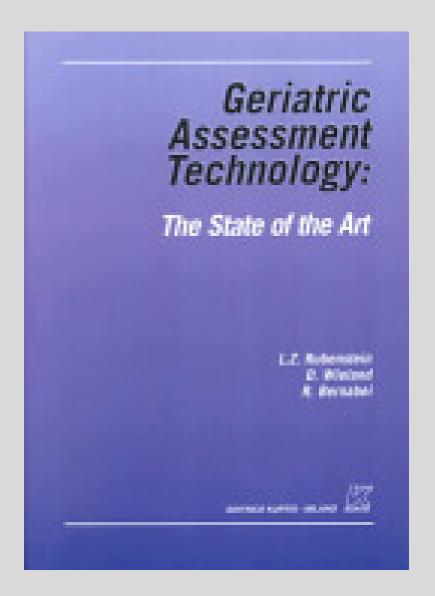




Six-month survival by FI-combined scores, in 427 older Emergency Dept patients consulted to Medicine









Relationship between the number of drugs prescribed to an older adult and the chance of an adverse drug reaction

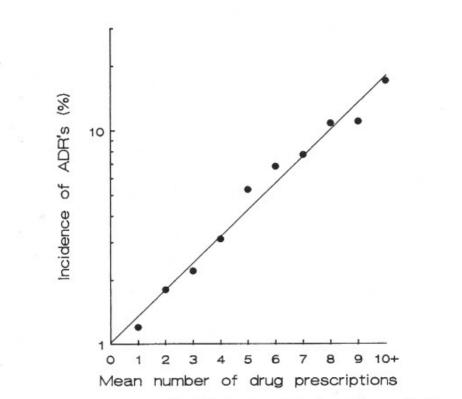


FIGURE 4. Incidence of ADR's (on logarithmic scale) stratified by number of drug prescriptions administered during hospitalization to each patient. Chi-square in 2×10 table = 349, P < 0.0001.



Learning from other complex systems applications







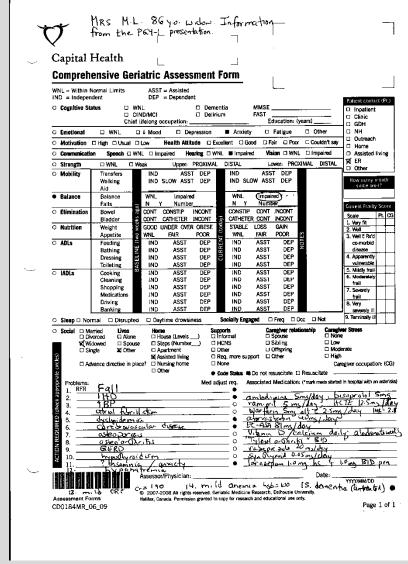


The team conference



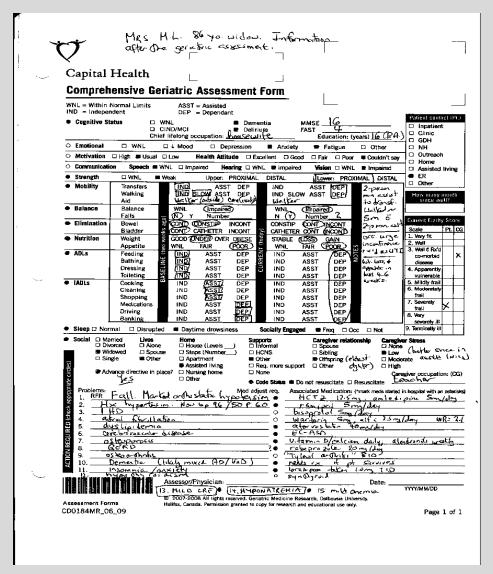


Stratifying frailty based on a CGA: data in a standard PGY-1 IM, hx & pe



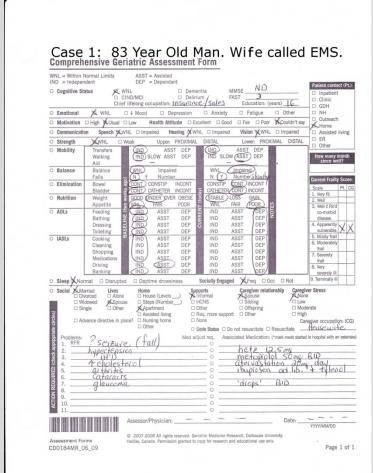


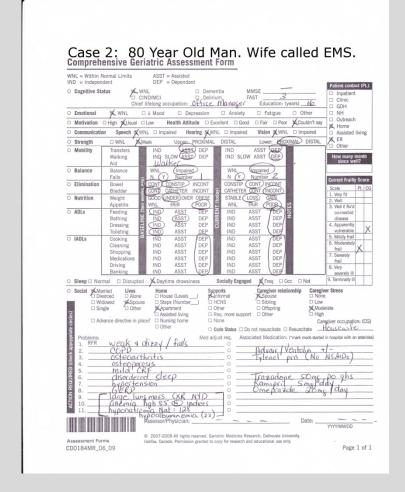
What is added by a Comprehensive Geriatric Assessment





Which patient is the more frail? Which patient is the more acutely ill?







Measuring mobility: the HABAM

- The Hierarchy of Balance and Mobility
- In bed-mobility
- Cannot move off pressure points
- Moves side to side
- Can push to sit up
- Can swing legs over the side of the bed

MacKnight & Rockwood *Age Ageing* 1995;24:126-30 MacKnight & Rockwood *J Clin Epidemiol* 2000;53:1242-1247

Rockwood et al. J Am Geriatr Soc, 2008;56:1213-1217.





Assessment of Balance and Mobility: embracing complexity through pattern recognition in a state variable

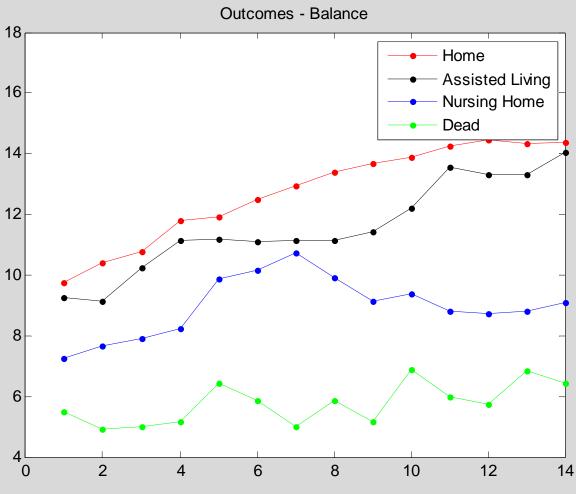
Hierarchical Assessment of Balance and Mobility

Figure 1. Scores for two patients over their hospital course.

Date Assessed										
Instrument Day	01	02	03	04	05	06	07	08	09	10
BALANCE										
21. stable ambulation										
14. stable dynamic standing							•	•		
10. stable static standing					•	•				
7. stable dynamic sitting	A			•						
5. stable static sitting	•	●,▲	•							
0. impaired static sitting			A	A						
TRANSFERS										
18. independent							•	•		
12. 1 person standby						•				
11. 1 person minimal assist					•					
7. 1 person assist				•						
3. 2 person assist	●, ▲	•	•							
0. total lift			A							
MOBILITY										
26. unlimited										
25. limited > 50m										
21. unlimited with aid										
18. with aid >50m							•	•		
15. with aid 8-50m						•				
12. 1 person standby/+/- aid					•					
9. 1 person hands-on/+/-aid				•						
7. lying-sitting independently	A		•							
4. positions self in bed	•	●,▲								
0. needs positioning in bed			A	A						



Mean value of first 14-day HABAM scores by discharge disposition



Hubbard et al., J Gen Intern Med 2012;26(12):1471-8



Clinical Frailty Scale*



Very Fit – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.



2 Well – People who have no active disease symptoms but are less fit than category 1. Often, they exercise or are very active occasionally, e.g. seasonally.



3 Managing Well – People whose medical problems are well controlled, but are not regularly active beyond routine walking.



4 Vulnerable – While not dependent on others for daily help, often symptoms limit activities. A common complaint is being "slowed up", and/or being tired during the day.



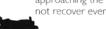
5 Mildly Frail – These people often have more evident slowing, and need help in high order IADLs (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.



6 Moderately Frail - People need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing and might need minimal assistance (cuing, standby) with dressing.



Severely Frail – Completely dependent for personal care, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).



8 Very Severely Frail – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.



9. Terminally III - Approaching the end of life. This category applies to people with a life expectancy <6 months, who are not otherwise evidently frail

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common symptoms in mild dementia include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In moderate dementia, recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In severe dementia, they cannot do personal care without help.

- * I. Canadian Study on Health & Aging, Revised 2008.
- 2. K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAI 2005;173:489-495.

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List of Frailty:

- 1. Very Fit
- 2. Well
- 3. Managing Well
- 4. Vulnerable
- 5. Mildly Frail
- 6. Moderately Frail
- 7. Severely Frail
- 8. Very Severely Frail
- 9. Terminally ill

I measure of fitness 005: 173:489-495





Risk of death within 30 days in relation to HABAM scores

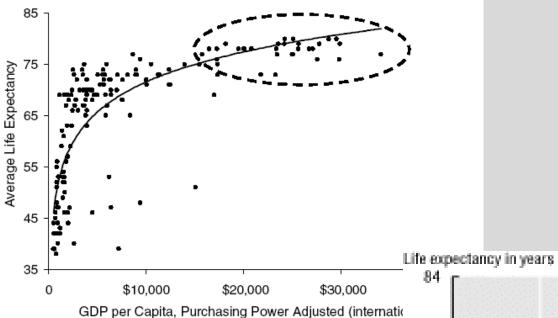
- Absolute risk of death if:
 - mobility & balance was no worse (same/better) in the first 48 hours:
 - mobility only was worse in the first 48 hours:
 8%
 - mobility & balance was worse in the first 48 hours:



The argument in brief (2)

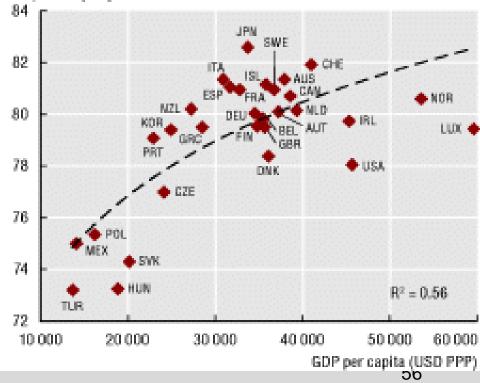
- 5. Frail older adults challenge health care systems, by having multiple, interacting health and social problems.
- 6. When our system was designed, the median age of the population was 27 year; single organ system illness was the norm.
- 7. Health care has benefitted greatly from subspecialization. People with one thing wrong still do.
- 8. For the frail older patient that time has passed; we must innovate, or lose Medicare.





Note: Because of its very high GDP, Luxembourg was excluded to simplify the vis presentation (life expectancy = 77, GDP = \$50,061).

Source: World Bank 2002.



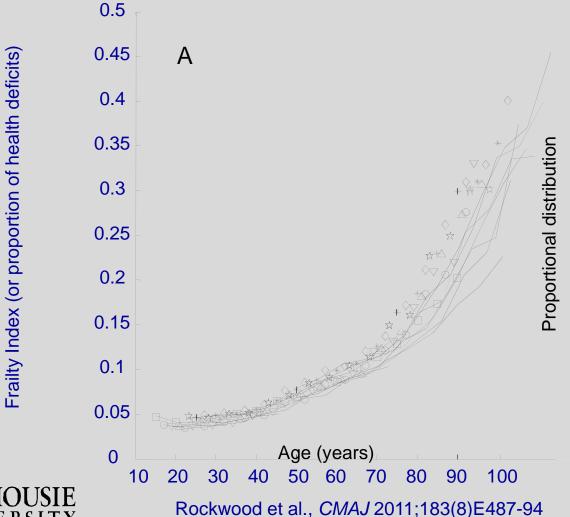


100 Fried: 80 robust prefrail participant number frail 60 40 20 0.1 0.2 0.3 0.5 0.6 0.7 0.8 0.0 0.4 Rockwood frailty index В 100 80 Fried frequencies (%) 60 40 20 0 0.2 0.0 0.1 0.3 0.4 0.5 0.6 Rockwood frailty index Fried: □ robust pre-frail frail

Collerton et al., Mech Ageing Dev 2012;133(6):



Deficits accumulate characteristically at all adult ages



National
Population
Health Survey Mean Frailty
Index at each
cycle in relation
to age



New drugs and new interventions addrive costs; both are heavily used by older adults, to unclear benefit

