

Using the CLSA to understand the role of mobility testing in fall risk assessment for community-dwelling older adults

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REACHING FURTHER



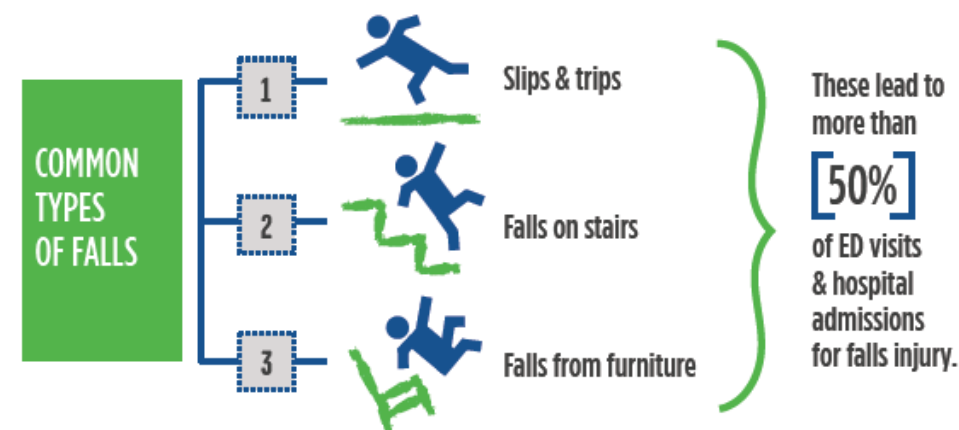
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Outline

- Background on falls and mobility/balance
- Fall risk assessment and prevention guidelines
- CLSA analysis methods and results
- Clinical and research implications

Burden of falls in Canada

- Leading cause of injury-related hospitalization among older adults¹
- Associated with longest LOS compared to all other causes¹
- \$3.3 billion dollars/yr in direct health care costs²
- Leads to activity restriction, long-term care admission and death^{1,3}



The Patient Who Falls

"It's Always a Trade-off"

Mary E. Tinetti, MD; Chandrika Kumar, MD

JAMA. 2010;303(3):258-266. doi:10.1001/jama.2009.2024

Risk Factor	Studies in Which Factor Was Significant ^c		Ranges of Adjusted Values ^d	
	No.	References (Listed in eAppendix)	RR	OR
Previous falls	16	1, 2, 5, 6, 7, 9, 10, 11, 15, 17, 18, 19, 21, 25, 26, 29	1.9-6.6	1.5-6.7
Balance impairment ^e	15	1, 4, 5, 7, 9, 12, 13, 17, 18, 19, 22, 24, 28, 30, 31	1.2-2.4	1.8-3.5
Decreased muscle strength (upper or lower extremity) ^e	9	4, 6, 9, 18, 19, 21, 24, 25, 26	2.2-2.6	1.2-1.9
Visual impairment	8	8, 11, 15, 16, 13, 22, 29, 30	1.5-2.3	1.7-2.3

Falls can be prevented

- Risk factor identification with tailored intervention can reduce both the rate and risk of falls by 25-40%^{1,2}
 - Functional exercises that challenge *balance* have greatest impact on falls



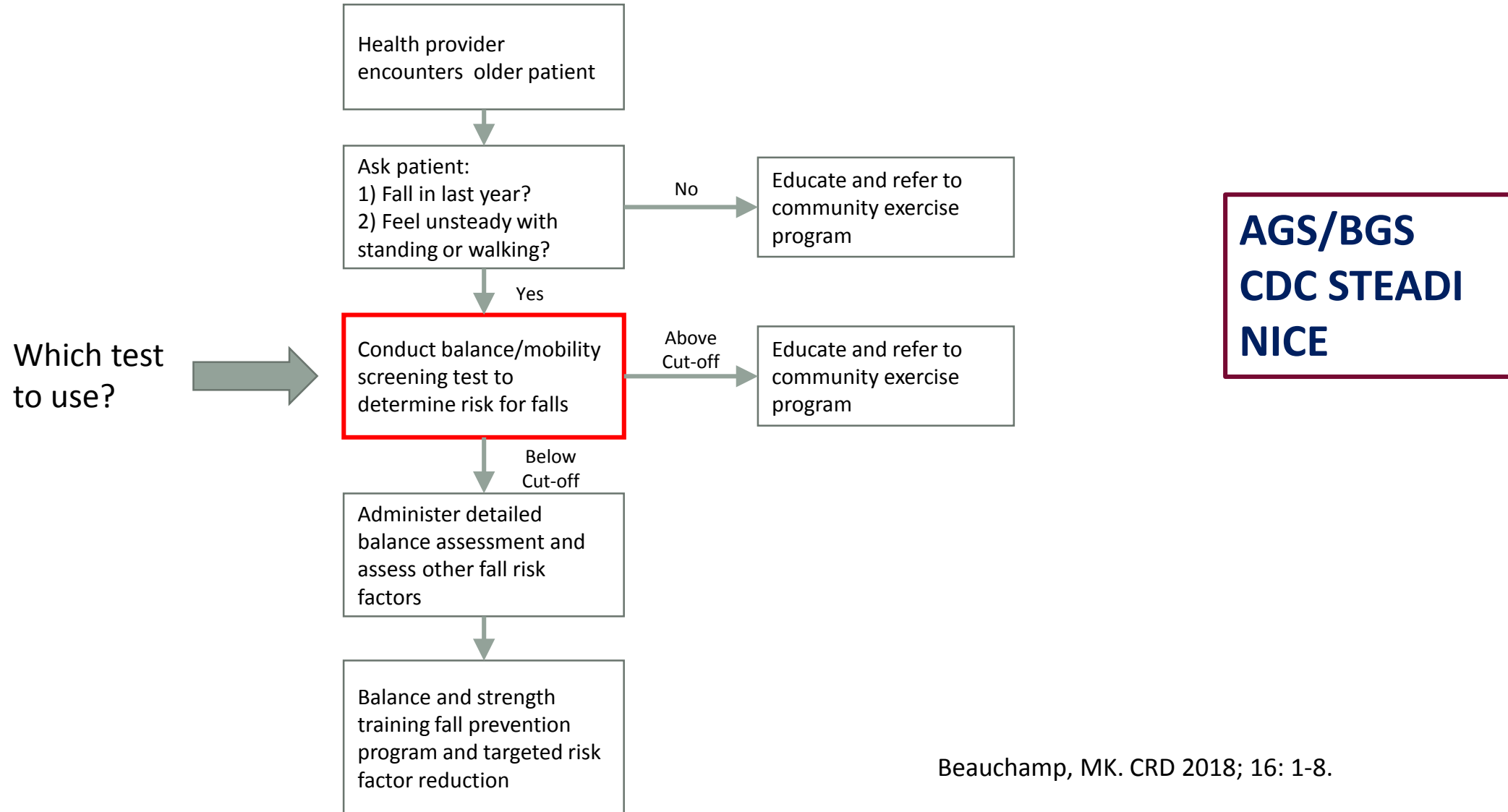
"Comic" from <https://twitter.com/NgaireHobbins>

¹ Sherrington et al. Cochrane Database Syst Rev 2019; ²Tricco et al. JAMA 2017

Fall prevention guidelines

- Produced by a number of different organizations
- American and British Geriatrics Societies (AGS/BGS), National Institute for Health and Care Excellence (NICE), and the CDC Stopping Elderly Accidents, Deaths and Injuries (STEADI) most common
- Tests of balance and mobility recommended by each

Fall risk assessment and prevention algorithm



Beauchamp, MK. CRD 2018; 16: 1-8.

Which test to use and at what cut-off?

- Need short, easy to administer tests for screening
- Only 1 CPG includes cut-off values to identify those who are impaired
 - CDC recommends ≥ 12 seconds on the TUG for risk of falling
 - Cut-offs also suggested for the optional standing balance test and chair-stand test
 - Limited research to support endorsed cut-offs

Study aim

To determine the accuracy and cut-off values of commonly used screening tests of balance and mobility for predicting falls in community-dwelling older adults

CLSA Research Platform

50,000 participants aged 45 - 85 at baseline

Target: 20,000
Actual: 21,241
Randomly selected within
provinces

Target: 30,000
Actual: 30,097
Randomly selected
within 25-50 km of 11 sites

Questionnaire
By telephone (CATI)

Questionnaire
In person, in home (CAPI)

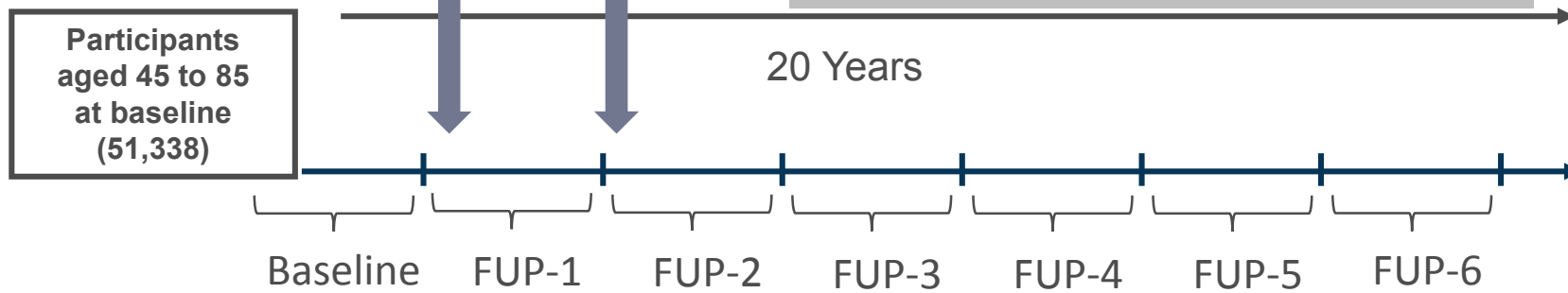
2010 - 2015

2015

2018

Clinical/physical tests
Blood, urine
@ Data Collection Site

2033



Active follow-up every 3 years

Methods

- Study design
 - Secondary analysis of baseline and 18 month follow-up data from the CLSA comprehensive cohort
- Sample (in line with guidelines)
 - Participants > 65 years at baseline
 - Reported injury due to a fall in the last 12 months or who reported difficulty with mobility during ADL and IADLs (walking, transferring, community mobility, shopping or housework)

Identifying fallers at baseline in the CLSA

- In-home questionnaire (baseline comprehensive)
 - In the last 12 months, have you had any injuries that were serious enough to limit some of your normal activities? For example, a broken bone, a bad cut or burn, a sprain or a poisoning.
 - Was this injury (were any of these injuries) caused by a fall?
 - Again, thinking about this most serious injury, how did it happen?
 - Fall from same level; Fall from height

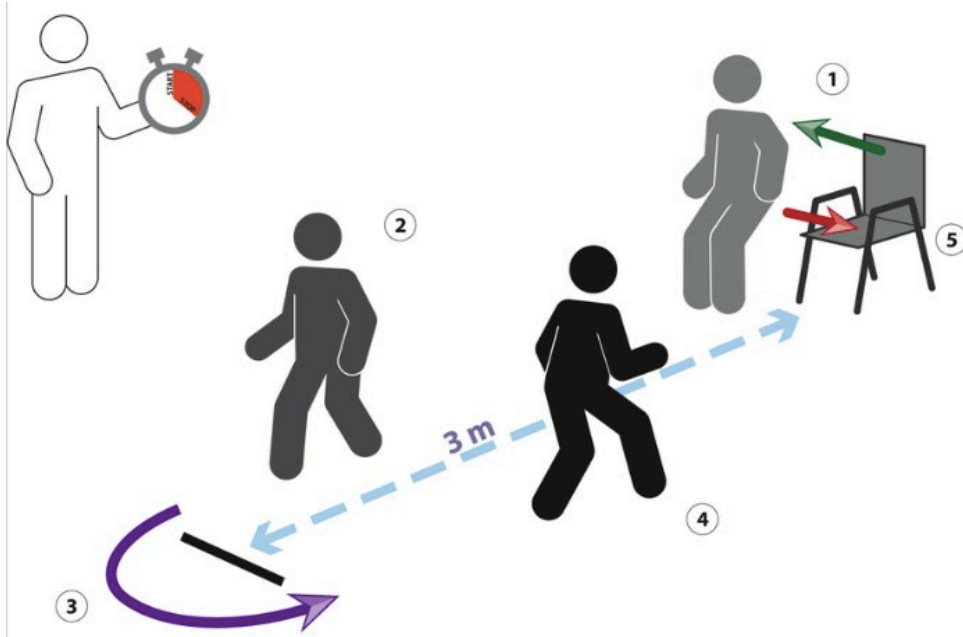
Falls at 18 months (outcome)

- Telephone interview (maintaining contact questionnaire administered by phone approx. 18 months after in-person visit)
 - I have two questions about whether you may have experienced any falls over the past 12 months. We are interested in falls where you hurt yourself enough to limit some of your normal activities. In the past 12 months, did you have any falls?
 - Any falls
 - How many times have you fallen in the past 12 months?
 - Multiple falls

Mobility and balance tests (exposures)

- Baseline comprehensive
 - Timed Up and Go (TUG)
 - Standing balance (single leg stance)
 - Chair-rise test
 - Gait speed

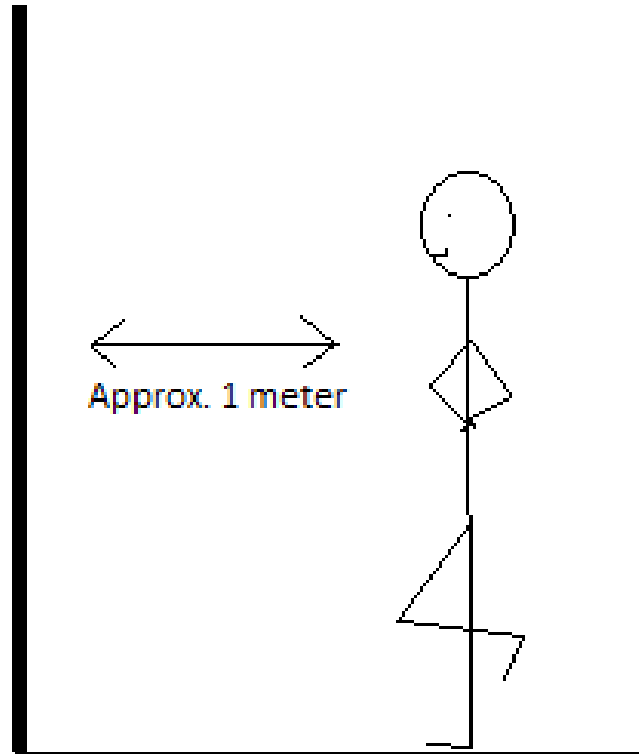
Timed Up and Go (TUG)



- Most widely suggested test by CPGs
- Data to support recommended cut-point (12 sec) is limited
 - Based on a single study in which falls were not measured as an outcome¹
- A recent systematic review evaluating the predictive validity for falls of the TUG showed inconsistent results²
- AUCs range from 0.60-0.72

¹Bischoff et al. Age and Ageing 2003; ²Park, Aging Clin Exp Res 2017

Standing balance test



- Participant is asked to stand on one foot (i.e., single leg stance) for up to 60 seconds
- <10 secs in last 2 positions suggested as a cut-off for risk of falling by CDC¹
- No studies supporting this cut-point with falls as outcome
- Low AUCs reported to date (<0.60)

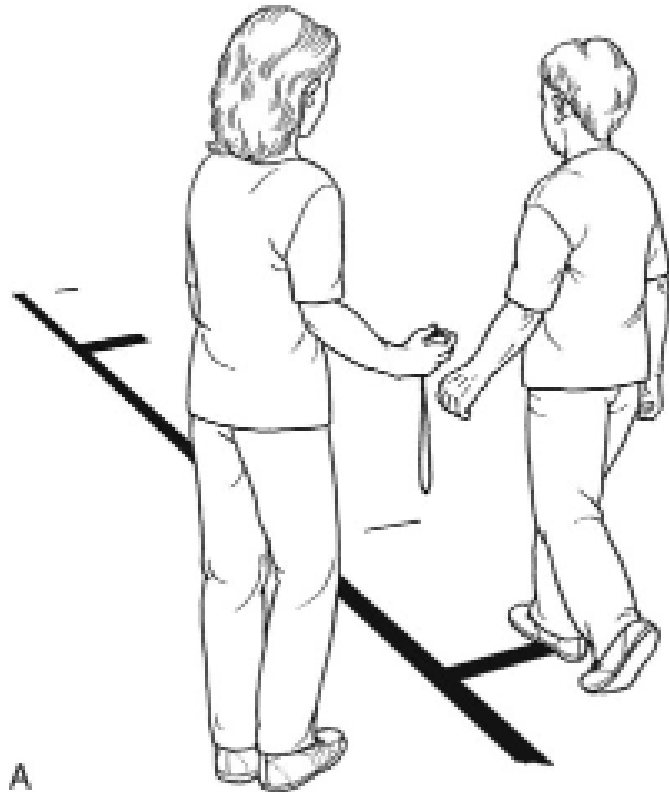
¹ Winograd JAGS 1994

Chair-Rise Test



- Time to complete 5 chair-stands
- Some evidence of predictive validity for falls but accuracy has not been reported
- No established cut-off values or AUC values reported to date

Gait speed



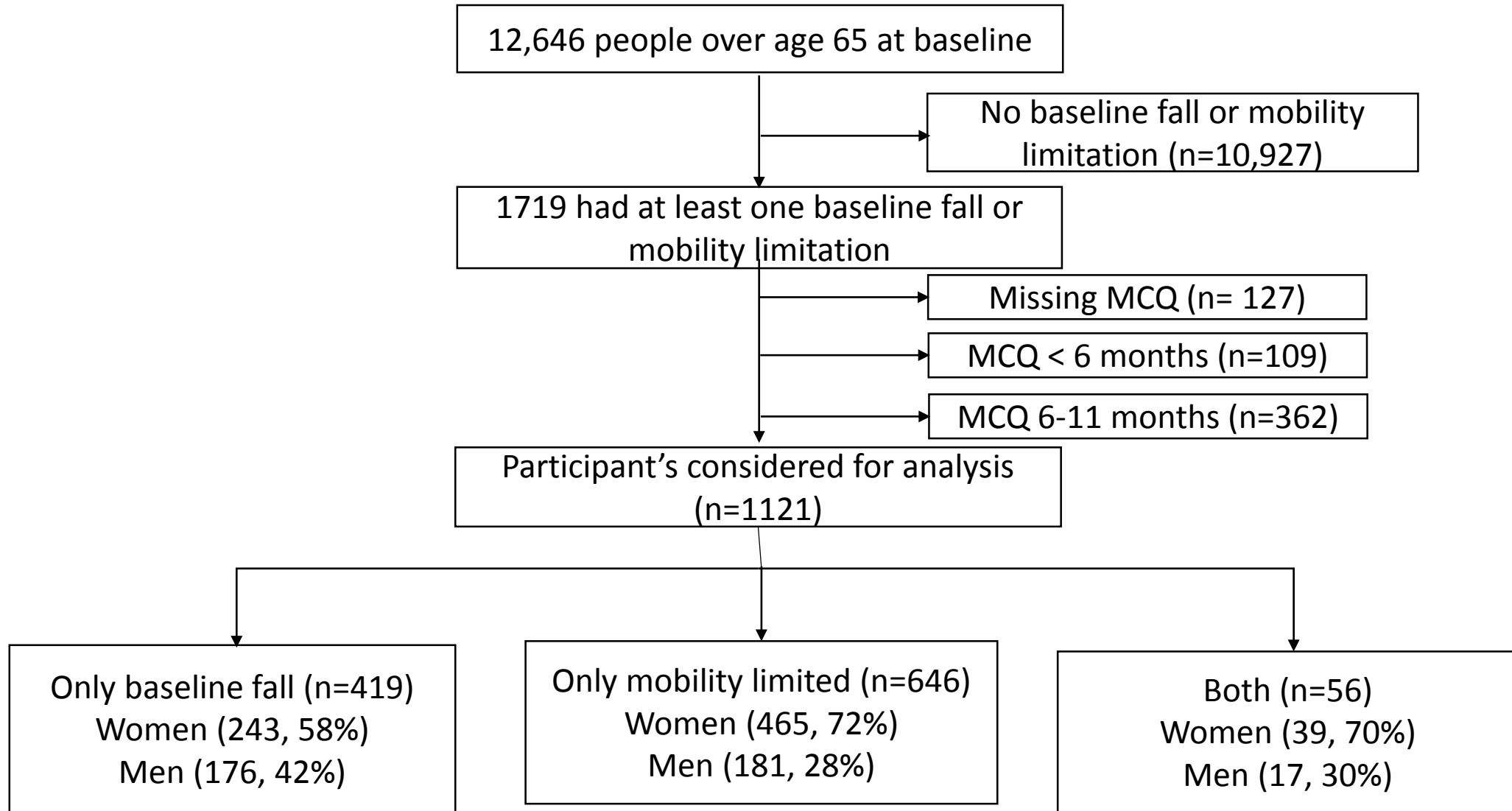
- Time in m/s to walk 4m at usual pace
- Inconsistent results for predicting falls
- Relationship between gait speed and falls may be non-linear¹

¹Quach et al, JAGS 2012

Statistical Analysis

- Accuracy for fall prediction for each screening test determined by the Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) curve
- Optimal cut-off value selected based on maximizing sensitivity and specificity for identifying fallers at 18 months (any falls, and multiple falls)
- An $AUC \geq 0.7$ was deemed acceptable for screening based on convention

Flow chart



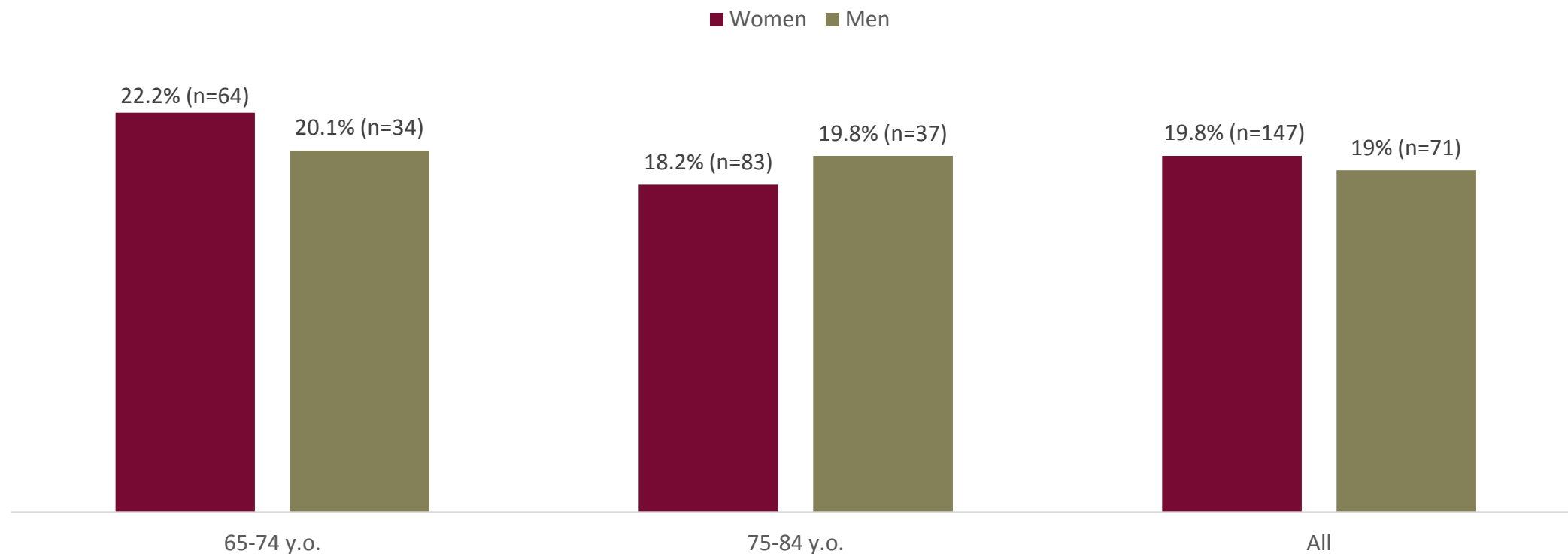
Sample Characteristics

Characteristic	Women (N=747)	Men (N=374)	Both (N=1121)
	Mean (SD) or N (%)	Mean (SD) or N (%)	Mean (SD) or N (%)
Mean age	75.5 (5.84)	74.8 (6.01)	75.2 (5.91)
# of CLSA chronic diseases			
• None	33 (4.5)	23 (6.2)	56 (5.0)
• 1-3	390 (52.8)	224 (60.2)	614 (55.3)
• 4+	316 (42.3)	125 (33.4)	441 (39.3)
Average # of chronic condition	3.25 (1.78)	2.82 (1.64)	3.11 (1.74)
CES-D (≥10)	196 (27.1)	74 (20.7)	270 (25.0)
Mental Alteration Test (<35)	60 (8.7)	32 (9.2)	92 (8.9)
Self-rated vision (fair or poor)	126 (16.9)	59 (15.8)	185 (16.5)
Education level (secondary school or less)	176 (23.6)	54 (14.5)	230 (20.6)
Household income (≤\$50,000)	383 (58.5)	115 (33.1)	498 (49.7)
Self-rated pain or discomfort (moderate or severe)	356 (48.4)	114 (30.8)	470 (42.5)
Medication for depression (yes)	131 (18.3)	50 (13.7)	181 (16.8)

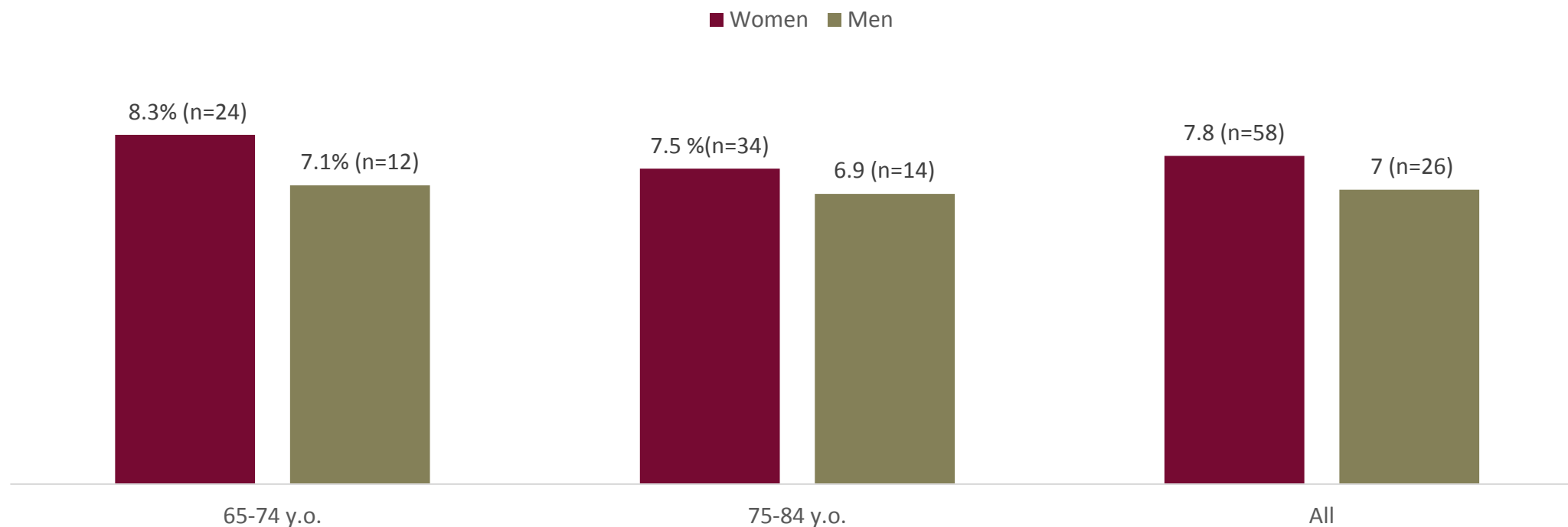
Baseline performance on tests (n=1121)

Screening tests	65-74				75-85			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Women								
TUG (s)	11.10	3.26	6.07	22.18	12.83	3.66	6.06	25.20
Gait speed (m/s)	0.86	0.22	0.27	1.42	0.75	0.20	0.31	1.36
Balance (s)	24.06	22.21	0.00	60.00	9.02	10.80	0.00	46.51
Chair-rise (s)	15.37	4.70	7.75	30.07	16.42	4.65	7.53	31.45
Men								
TUG (s)	11.31	3.61	5.97	27.24	12.53	3.73	6.58	24.36
Gait speed (m/s)	0.88	0.23	0.28	1.58	0.81	0.21	0.26	1.39
Balance (s)	28.18	24.36	0.00	60.00	14.89	18.18	0.00	60.00
Chair-rise (s)	14.75	4.19	6.82	27.84	15.59	4.20	6.22	30.64

Outcomes at 18 months: Any falls in the past 12 months



Outcomes at 18 months: Multiple falls in the past 12 months



Predictive accuracy for any falls in adults > 65 yrs.

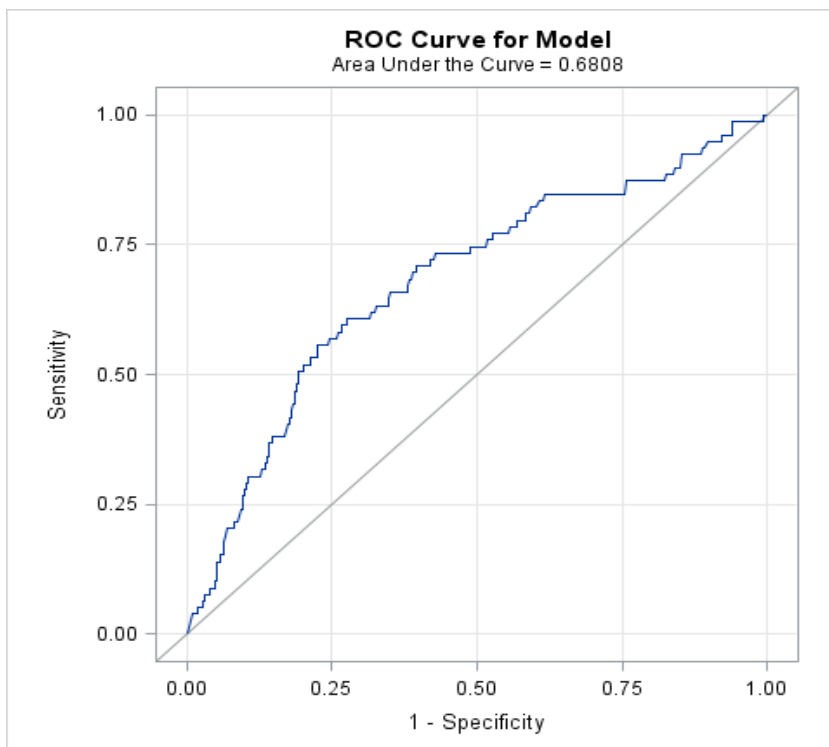
	Mobility only							Model with other risk factors*				
	N	Cut-off	AUC (CI)	Sens	Spec	PPV	NPV	AUC (CI)	Sens	Spec	PPV	NPV
TUG (s)	1056	14.21	0.60 (0.55,0.64)	0.36	0.82	0.32	0.84	0.64 (0.60,0.69)	0.56	0.69	0.31	0.86
Gait speed (m/s)	1063	0.73	0.57 (0.53,0.62)	0.47	0.66	0.25	0.83	0.63 (0.58,0.68)	0.54	0.70	0.30	0.86
Balance (s)	810	4.47	0.52 (0.47,0.58)	0.43	0.66	0.20	0.85	0.63 (0.57,0.68)	0.45	0.79	0.30	0.88
Chair-rise (s)	860	15.9	0.52 (0.47,0.57)	0.46	0.59	0.19	0.84	0.62 (0.57,0.68)	0.35	0.86	0.33	0.87

Predictive accuracy for multiple falls in adults > 65 yrs.

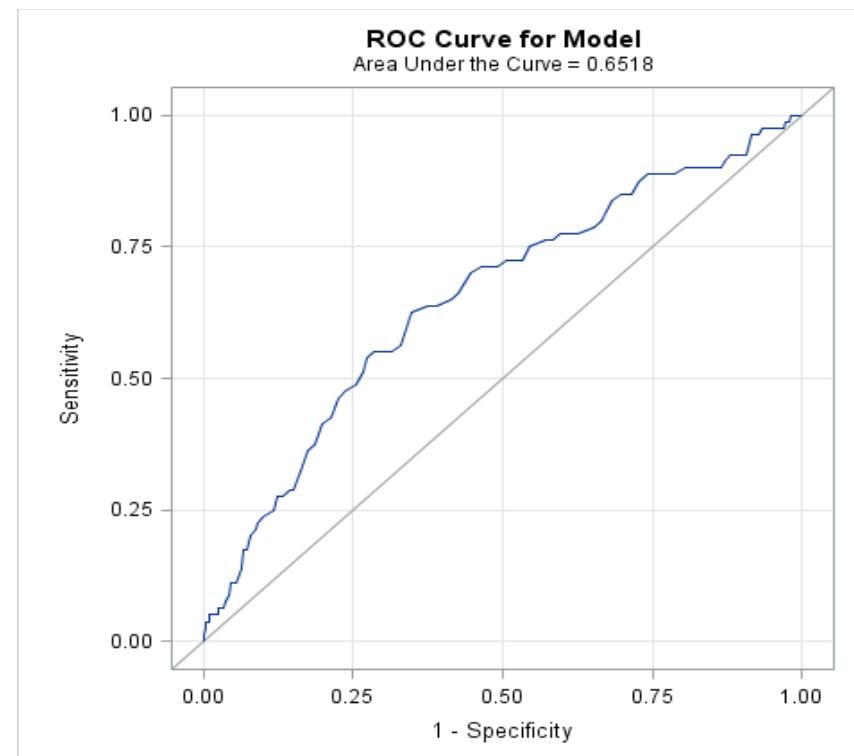
	Mobility only							Model with other risk factors*				
	N	Cut-off	AUC (CI)	Sens	Spec	PPV	NPV	AUC (CI)	Sens	Spec	PPV	NPV
TUG (s)	1056	13.71	0.68 (0.62,0.75)	0.56	0.78	0.17	0.96	0.74 (0.68,0.80)	0.70	0.72	0.17	0.97
Gait speed (m/s)	1063	0.73	0.65 (0.59,0.72)	0.63	0.65	0.13	0.96	0.72 (0.66,0.78)	0.68	0.69	0.15	0.96
Balance (s)	810	5.24	0.62 (0.53,0.71)	0.68	0.63	0.09	0.97	0.70 (0.60,0.80)	0.69	0.67	0.10	0.98
Chair-rise (s)	860	15.75	0.60 (0.51,0.69)	0.65	0.58	0.08	0.97	0.72 (0.62,0.81)	0.63	0.76	0.12	0.97

ROC curves for multiple falls

TUG AUC=0.68; cut-off 13.7 sec



Gait speed AUC=0.65; cut-off 0.73m/sec



Age and sex-stratified analyses

Predictive accuracy for any falls in women

	N	Cut-off	Mobility only				Model with other risk factors*					
			AUC (CI)	Sens	Spec	PPV	NPV	AUC (CI)	Sens.	Spec.	PPV	NPV
65-74 YEARS												
TUG (s)	276	11.1	0.60 (0.51,0.68)	0.53	0.64	0.30	0.83	0.70 (0.62,0.78)	0.75	0.62	0.36	0.90
Gait speed (m/s)	276	0.78	0.56 (0.48,0.65)	0.48	0.68	0.30	0.82	0.70 (0.62,0.78)	0.69	0.68	0.38	0.89
Balance (s)	236	4.47	0.52 (0.43,0.62)	0.35	0.77	0.28	0.82	0.68 (0.58,0.77)	0.62	0.68	0.34	0.87
Chair-rise (s)	243	15.53	0.57 (0.48,0.65)	0.56	0.61	0.27	0.84	0.69 (0.60,0.78)	0.61	0.69	0.34	0.87
75-85 YEARS												
TUG (s)	430	15.81	0.62 (0.55,0.69)	0.33	0.84	0.31	0.85	0.71 (0.64,0.78)	0.57	0.78	0.37	0.89
Gait speed (m/s)	433	0.73	0.59 (0.52,0.66)	0.61	0.56	0.23	0.86	0.69 (0.62,0.76)	0.82	0.51	0.27	0.93
Balance (s)	304	6.16	0.54 (0.46,0.62)	0.73	0.45	0.18	0.91	0.72 (0.63,0.80)	0.68	0.70	0.28	0.93
Chair-rise (s)	341	22.35	0.51 (0.42,0.60)	0.19	0.91	0.28	0.86	0.70 (0.61,0.78)	0.73	0.57	0.23	0.92

*Models included CES-D \geq 10, mental alteration test (MAT) < 35, fair or poor self-rated vision, secondary or less education, moderate or severe self-rated pain, use of psychotropic medication

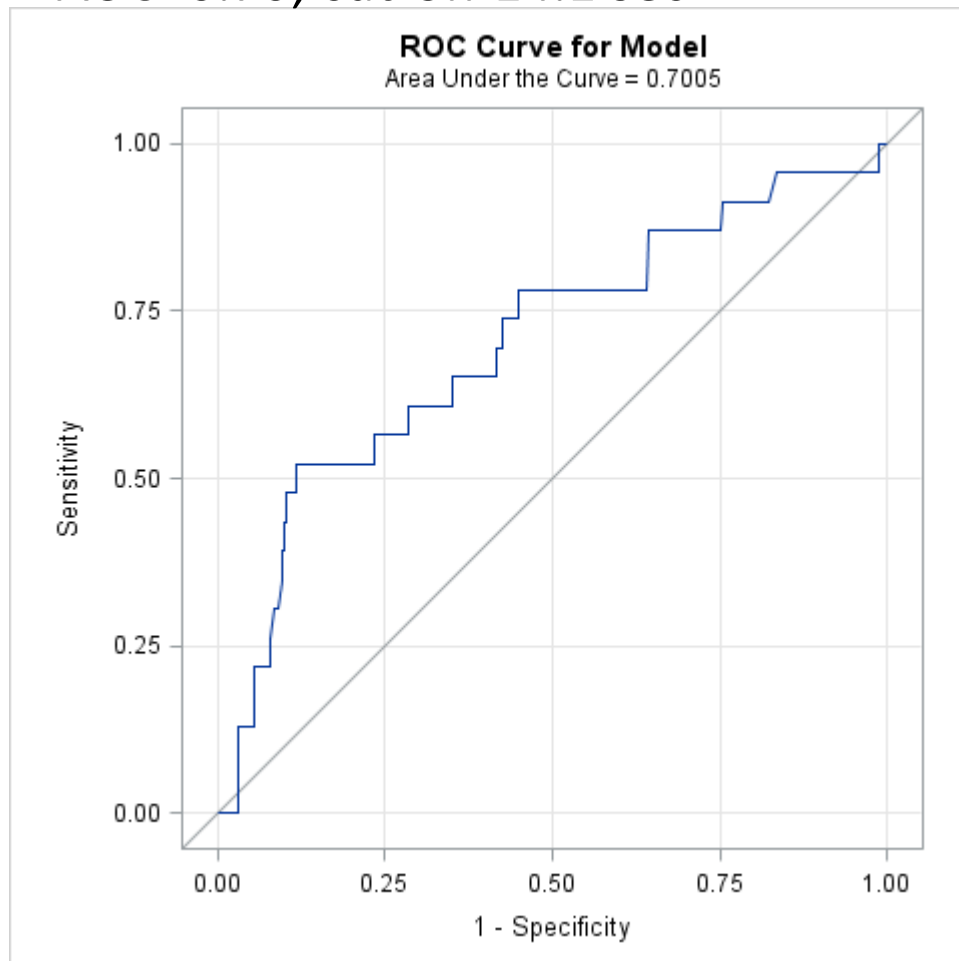
Predictive accuracy for multiple falls in women

	Mobility only							Model with other risk factors*					
	N	Cut-off	AUC (CI)	Sens	Spec	PPV	NPV	AUC (CI)	Sens	Spec	PPV	NPV	
65-74 YEARS													
TUG (s)	276	14.09	0.70 (0.58,0.82)	0.52	0.88	0.29	0.95	0.79 (0.67,0.90)	0.75	0.76	0.23	0.97	
Gait speed (m/s)	276	0.74	0.65 (0.52,0.78)	0.61	0.74	0.18	0.95	0.80 (0.69,0.91)	0.85	0.73	0.22	0.98	
Balance (s)	236	4.47	0.53 (0.34,0.72)	0.46	0.76	0.10	0.96	0.73 (0.58,0.89)	0.67	0.71	0.13	0.97	
Chair-rise (s)	243	16.47	0.66 (0.52,0.81)	0.67	0.69	0.13	0.97	0.78 (0.65,0.91)	0.71	0.75	0.17	0.97	
75-85 YEARS													
TUG (s)	430	12.91	0.70 (0.61,0.79)	0.70	0.64	0.14	0.96	0.72 (0.61,0.82)	0.67	0.73	0.17	0.96	
Gait speed (m/s)	433	0.70	0.68 (0.59,0.77)	0.70	0.62	0.13	0.96	0.73 (0.62,0.83)	0.78	0.65	0.15	0.97	
Balance (s)	304	6.16	0.60 (0.50,0.70)	0.88	0.44	0.08	0.98	0.78 (0.67,0.90)	0.92	0.61	0.11	0.99	
Chair-rise (s)	341	16.6	0.63 (0.50,0.75)	0.61	0.59	0.08	0.96	0.73 (0.59,0.86)	0.53	0.85	0.16	0.97	

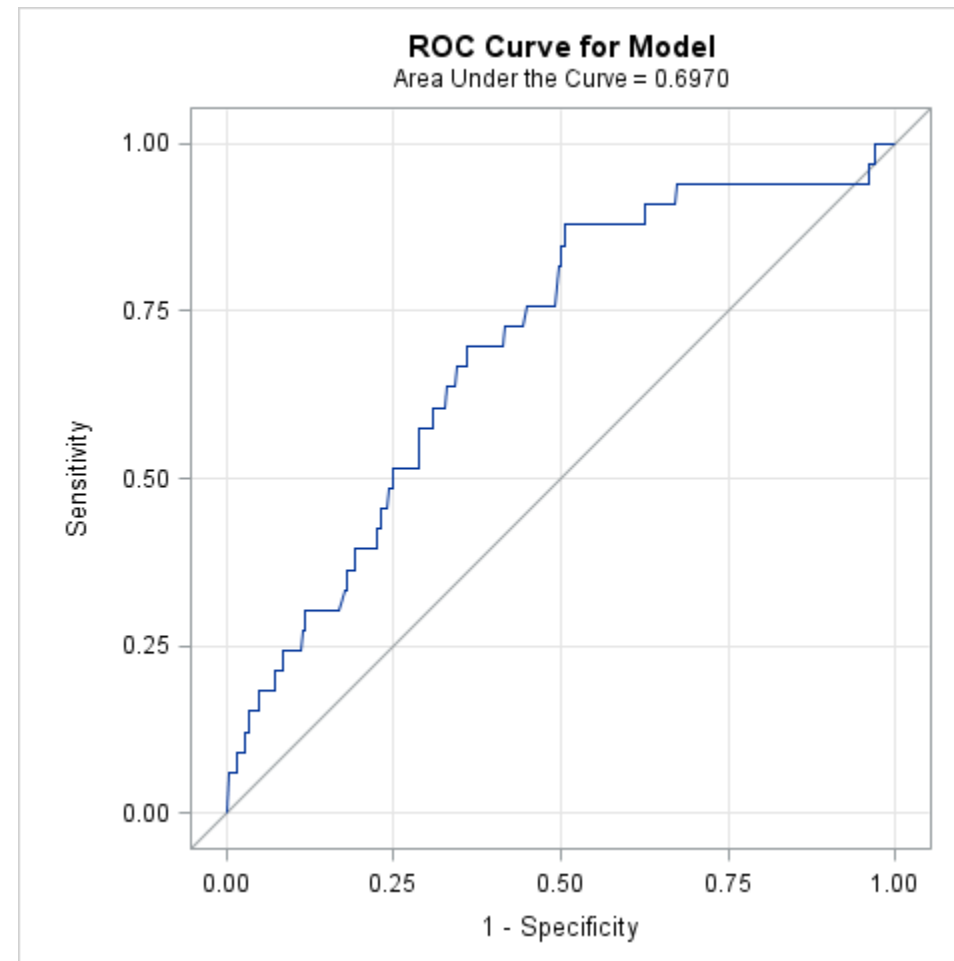
*Models included for CES-D \geq 10, mental alteration test (MAT) < 35, fair or poor self-rated vision, secondary or less education, moderate or severe self-rated pain, use of psychotropic medication

TUG identifies multiple fallers in women

TUG in women 65-74yrs:
AUC=0.70; cut-off 14.1 sec



TUG in women 75-84yrs:
AUC=0.70; cut-off 12.9 sec



Predictive accuracy for any falls in men

	Mobility only							Model with other risk factors*				
	N	Cut-off	AUC (CI)	Sens	Spec	PPV	NPV	AUC (CI)	Sens	Spec	PPV	NPV
65-74 YEARS												
TUG (s)	158	15.25	0.58 (0.46,0.71)	0.28	0.91	0.45	0.83	0.68 (0.56,0.79)	0.52	0.80	0.41	0.86
Gait speed (m/s)	157	0.85	0.57 (0.45,0.68)	0.56	0.58	0.26	0.84	0.65 (0.53,0.78)	0.38	0.93	0.58	0.85
Balance (s)	135	24.34	0.63 (0.51,0.75)	0.73	0.50	0.26	0.89	0.67 (0.54,0.81)	0.70	0.63	0.31	0.90
Chair-rise (s)	131	20.15	0.50 (0.37,0.63)	1.00	0.10	0.21	1.00	0.71 (0.59,0.83)	0.70	0.64	0.33	0.89
75-85 YEARS												
TUG (s)	192	13.91	0.63 (0.51,0.75)	0.54	0.80	0.37	0.89	0.69 (0.58,0.80)	0.66	0.71	0.34	0.90
Gait speed (m/s)	197	0.66	0.60 (0.49,0.72)	0.44	0.80	0.33	0.86	0.66 (0.56,0.77)	0.61	0.73	0.35	0.89
Balance (s)	135	14.16	0.57 (0.39,0.74)	0.47	0.73	0.18	0.92	0.72 (0.60,0.85)	0.79	0.62	0.22	0.95
Chair-rise (s)	145	18.58	0.52 (0.39,0.66)	0.94	0.23	0.14	0.97	0.70 (0.57,0.83)	0.94	0.41	0.19	0.98

*Models included for CES-D \geq 10, mental alteration test (MAT) < 35, fair or poor self-rated vision, secondary or less education, moderate or severe self-rated pain, use of psychotropic medication

Predictive accuracy for multiple falls in men

	Mobility only							Model with other risk factors*				
	N	Cut-off	AUC (CI)	Sens	Spec	PPV	NPV	AUC (CI)	Sens	Spec	PPV	NPV
65-74 YEARS												
TUG (s)	158	11.66	0.68 (0.51,0.86)	0.60	0.71	0.12	0.96	0.85 (0.76,0.95)	1.00	0.63	0.16	1.00
Gait speed (m/s)	157	0.85	0.67 (0.53,0.82)	0.70	0.57	0.10	0.97	0.84 (0.74,0.94)	1.00	0.59	0.15	1.00
Balance (s)	135	3.63	0.85 (0.69,1.00)	0.88	0.83	0.24	0.99	0.97 (0.94,1.00)	1.00	0.87	0.33	1.00
Chair-rise (s)	131	19.03	0.53 (0.26,0.81)	1.00	0.15	0.05	1.00	0.98 (0.95,1.00)	1.00	0.88	0.32	1.00
75-85 YEARS												
TUG (s)	192	13.91	0.64 (0.44,0.85)	0.69	0.77	0.18	0.97	0.76 (0.62,0.90)	0.82	0.73	0.17	0.98
Gait speed (m/s)	197	0.66	0.61 (0.43,0.80)	0.50	0.77	0.14	0.95	0.74 (0.63,0.86)	0.75	0.72	0.17	0.97
Balance (s)	135	14.16	0.56 (0.21,0.91)	0.50	0.72	0.05	0.98	0.90 (0.78,1.00)	1.00	0.81	0.13	1.00
Chair-rise (s)	145	18.53	0.61 (0.25,0.98)	1.00	0.23	0.04	1.00	0.91 (0.79,1.00)	1.00	0.77	0.09	1.00

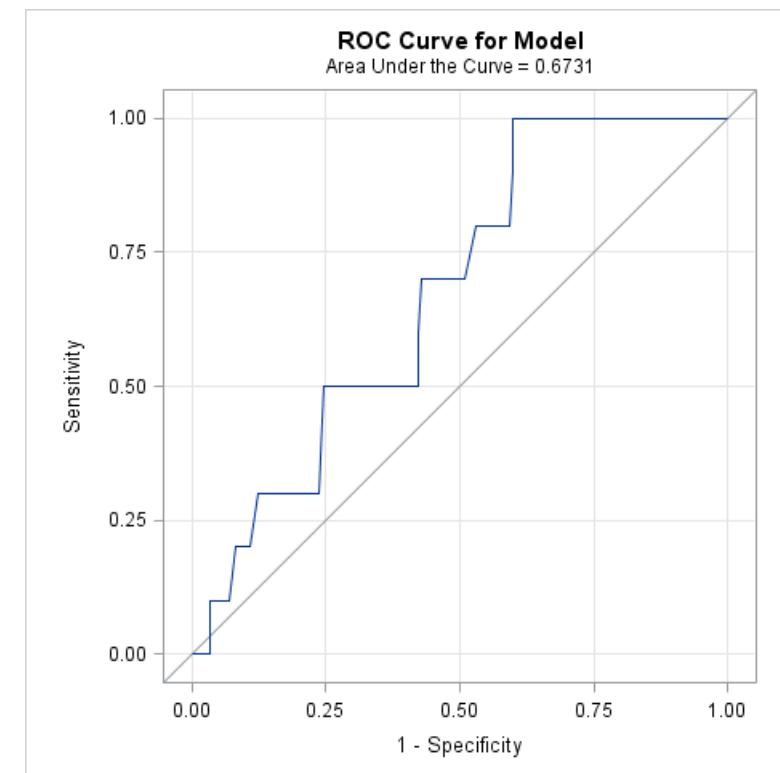
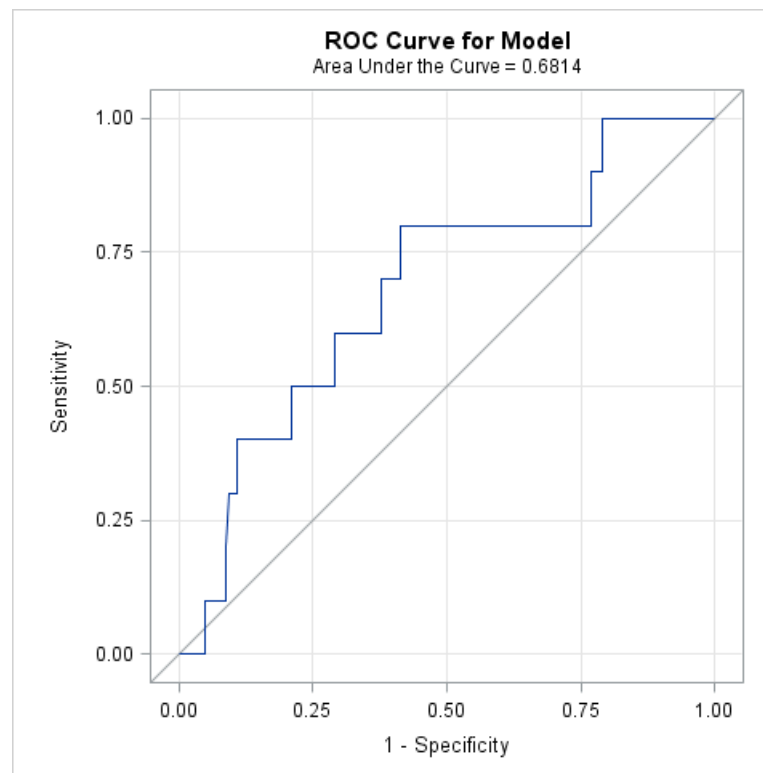
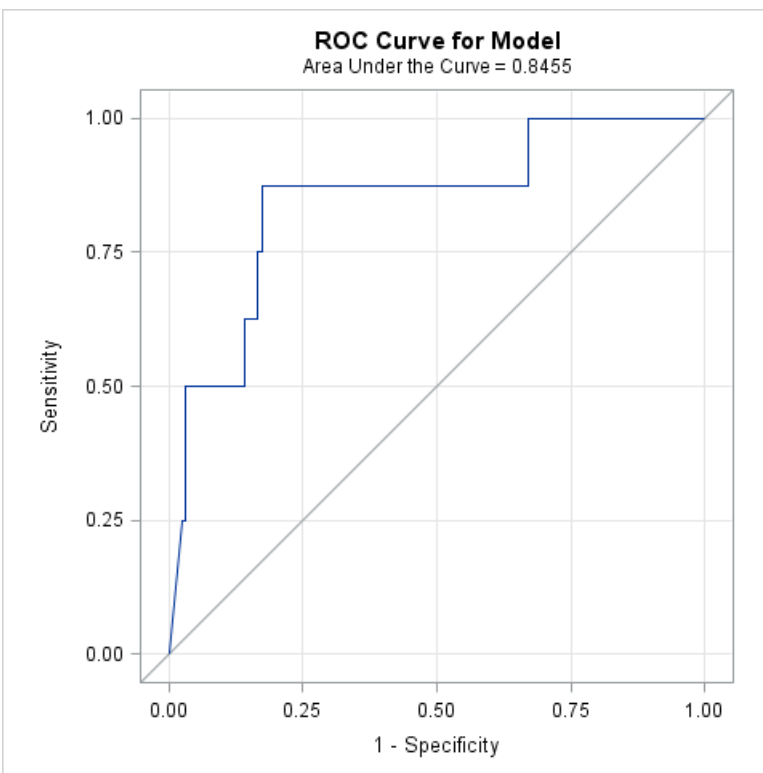
*Models included for CES-D \geq 10, mental alteration test (MAT) < 35, fair or poor self-rated vision, secondary or less education, moderate or severe self-rated pain, use of psychotropic medication

Balance best identifies multiple fallers in men

Balance in men 65-74 yrs:
AUC = 0.85; cut-off 3.6 sec

TUG in men 65-74 yrs:
AUC = 0.68; cut-off 11.7 sec

Gait speed in men 65-74 yrs:
AUC = 0.67; cut-off 0.85 m/sec



Overall findings

- None of the mobility and balance screening tests were able to predict just one fall at 18 months
 - Mobility/balance tests with higher difficulty level and more items may have higher accuracy
 - Consideration of a fall risk index in future work
- Can identify those at the highest risk for repeat falls
- Optimal cut-off values and predictive accuracy were different for men vs women and across age groups

Which test is best?

- In women, the Timed Up and Go (TUG) had the best accuracy for predicting multiple falls:
 - Women aged 65-74: TUG \geq 14.1 sec (AUC = 0.70)
 - Women aged 75-85: TUG \geq 12.9 sec (AUC= 0.70)
- In men, the single leg balance test had the best accuracy for predicting multiple falls:
 - Men aged 65-74: Standing balance \leq 3.6 sec (AUC = 0.85)
 - Men aged 65-74: TUG \geq 11.7 sec (AUC = 0.68)

Limitations

- Wording of fall/mobility questions differed from guidelines
- Smaller sample size in men with fewer fall events
 - More research needed in men 75+
- Individuals at highest risk may have been less likely to attend in person assessment
- Participants with worse balance/mobility may have been contraindicated to perform the tests as part of the study

Conclusions

- Clinical practice guidelines for fall risk assessment in community-dwelling older adults may need to consider age and sex-specific mobility screening tests and cut-off values
- Future work should evaluate other screening tests or a fall risk index that incorporates other risk factors
- Prospective studies designed to answer questions about fall risk screening are needed to draw definitive conclusions

Acknowledgements

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Questions?