

Vision, Eye Disease, and the Onset of Balance Problems

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Research Program Themes

1. Determine the frequency of visual impairment and eye disease
2. Understand risk factors for visual impairment and eye disease
3. Examine the impact of eye disease on mobility, mental, and physical health in older adults
4. Develop and test interventions

Background on Vision and Eye Disease

What is visual function?

Static

- Visual acuity
- Contrast sensitivity
- Visual field

Dynamic

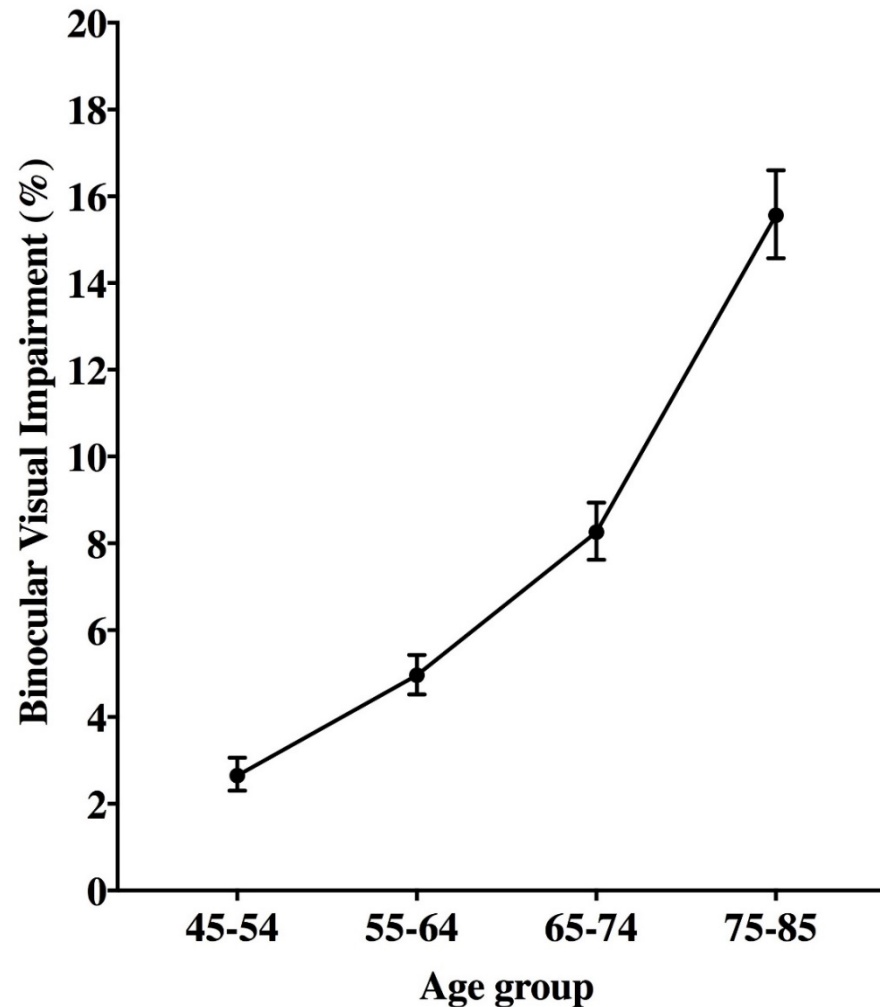
- Motion detection



Visual impairment

- In developed countries, VI is typically defined as visual acuity worse than 20/40
- WHO defines it as worse than 20/60

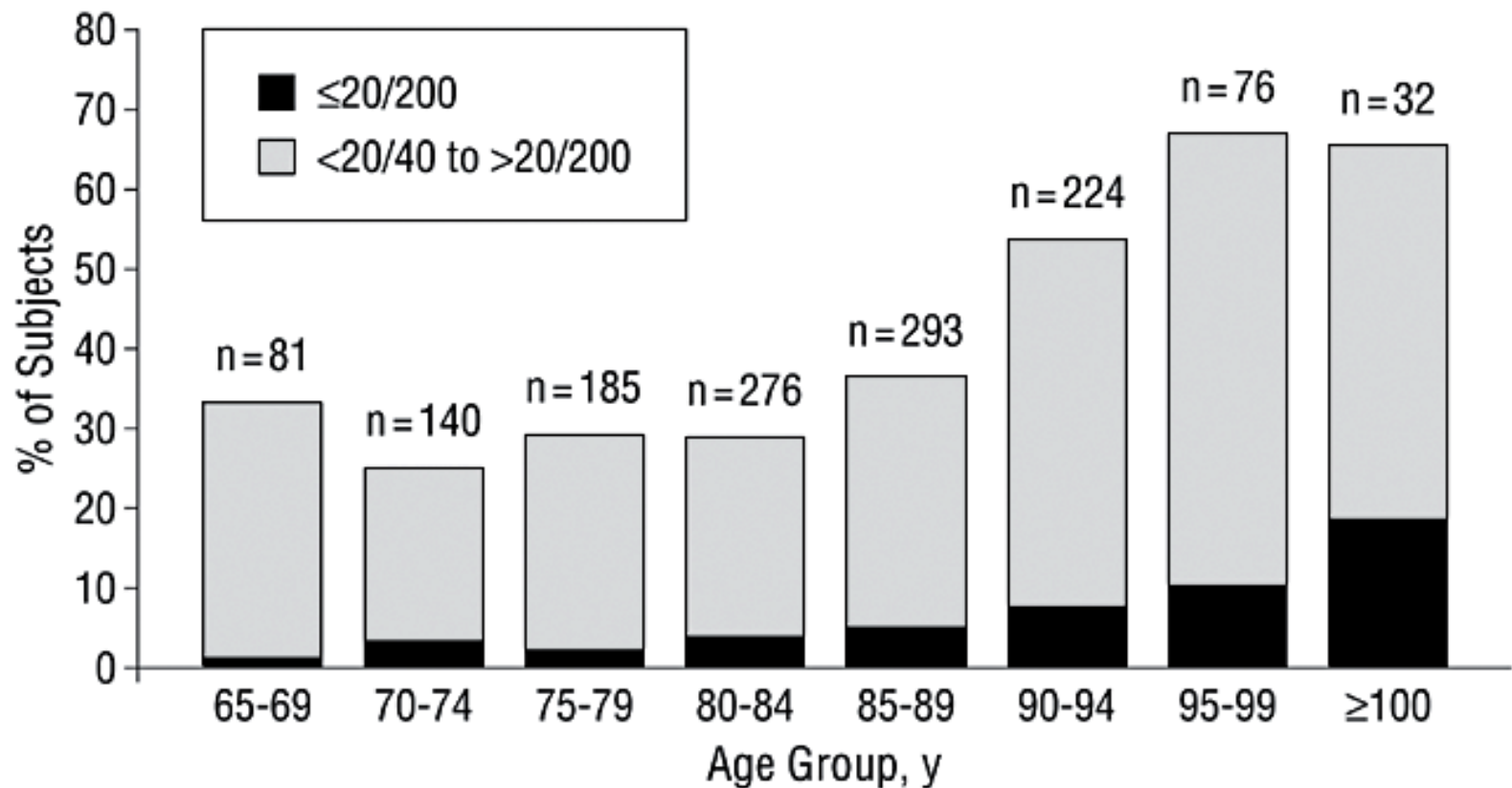
Prevalence of Visual Impairment in the Community



5.7% had VI

Aljied, Aubin, Buhrmann, Sabeti, Freeman. Prevalence and determinants of visual impairment in Canada: Cross-sectional data from the CLSA, *Can J Ophthalmol*, 2018

Prevalence of Visual Impairment and Blindness in Nursing Homes



DS Friedman et al. Arch Ophthalmol. 2004 Jul;122(7):1019-24): 416-423.

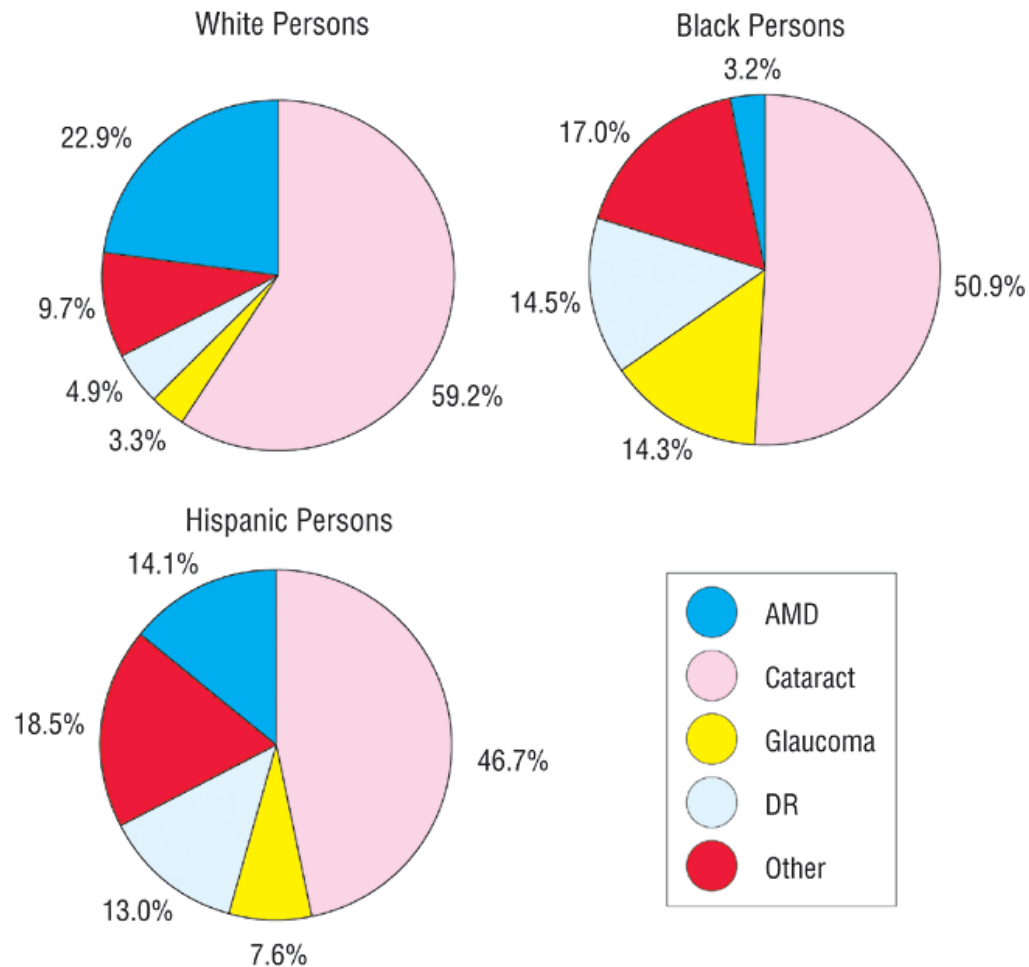
H Kergoat, Can Geriatr J, 2014, Perceived Needs and Availability of Eye Care...

The leading cause of visual
impairment is...

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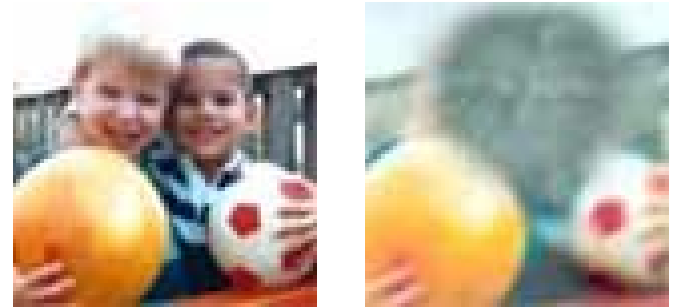


Other Causes of Visual Impairment

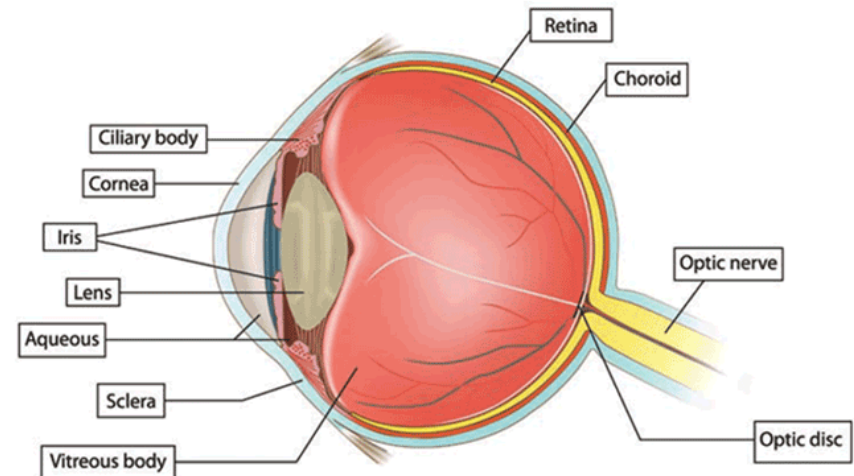


Age-Related Macular Degeneration

- Destroys central vision
- Often bilateral
- Two types:
 - Wet
 - Dry
- Some treatments available for wet AMD (e.g. anti-VEGF therapy)



National Eye Institute, USA



Glaucoma

- First affects peripheral vision
- Typically bilateral
- 50% of cases are undiagnosed
- There are many types of glaucoma; open-angle glaucoma is most common
- Treatment involves eye drops, laser, or surgery to lower eye pressure



National Eye Institute, USA

Cataract

- When the lens in your eye becomes cloudy
- Leads to blurry, hazy, less colorful vision
- Surgery can remove the clouded lens and replace it with an artificial lens



<https://www.aao.org/eye-health/diseases/what-are-cataracts>

Background on Mobility

Why Focus on Mobility?

- Mobility loss may be a preclinical stage of disability
 - Newman *et al* found that those in the worst quartile of 400-meter walk time had an increased risk of death, CVD, mobility limitations, and disability in a 5-year study of over 3000 older adults (JAMA 2006)



Intervene?

**Less Cognitive
Stimulation**

**Age-
Related
Eye
Disease**

**Mobility
Problems**

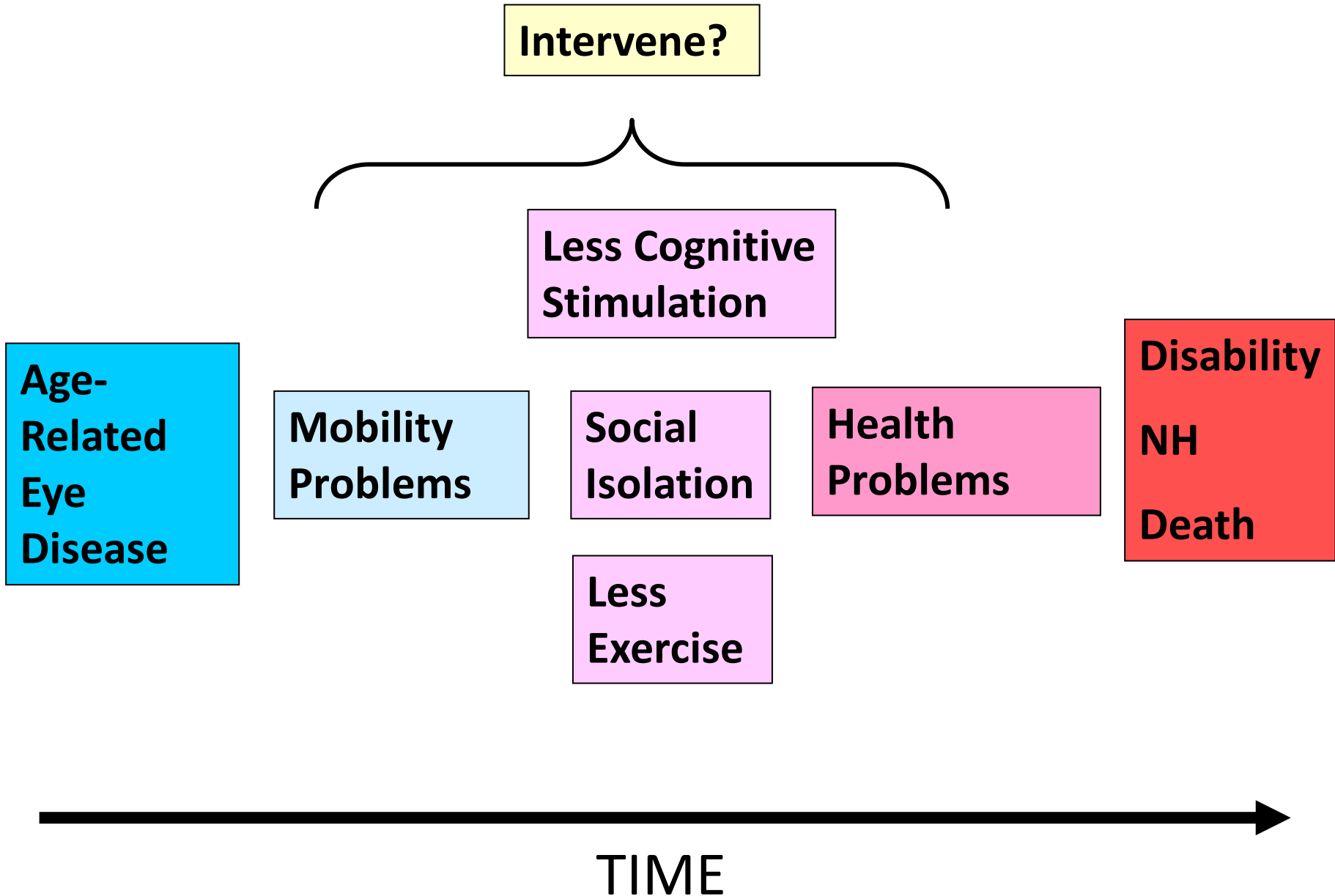
**Social
Isolation**

**Health
Problems**

**Less
Exercise**

**Disability
NH
Death**

TIME



Mobility

- How to assess independent mobility?
 - There is no gold standard test and the right test will depend on your question and your sample
 - Many requirements for full, unassisted mobility
 - maintain balance
 - walk
 - up and down from a chair or bed
 - up and down stairs
 - drive, take public transit, or get a ride

Balance is Central to Mobility

- Balance is controlled by several systems

Multisensory

- Visual system
- Somatosensory system
- Vestibular system

Musculoskeletal system



Cross-Sectional Research On Vision and Balance

Study	Design	Findings
Freeman/ Vafaei (2018)	CLSA	Acuity associated with balance
S. West (2008)	Population -based study	Acuity, contrast sensitivity, visual field, motion detection all associated with balance
C. West (2002)	Population -based study	Visual field and contrast sensitivity were associated with balance
Lord (2000)	Volunteers n=156	Postural sway was associated with contrast sensitivity on a compliant surface

Cross-Sectional Research On Eye Disease and Balance

Senior Author	Sample	Findings
Ramulu (2017)	Clinic	Balance of glaucoma patients was worse with greater visual field loss
Newman (2008)	Clinic	More postural sway in glaucoma patients with more visual field loss
Freeman (2011)	Clinic	Glaucoma patients had worse balance than those with normal vision No association with AMD

Very Few Longitudinal Studies

Study	Design	Findings
Baloh (2003)	Clinical study n=59	No association between visual acuity and change in balance
Kulmala (2011)	Finnish Twin Study n=313	No association between visual acuity and 3-year change in balance
Ostfeld (1994)	EPESE n=3133	Blind more likely to develop mobility limitations including balance loss

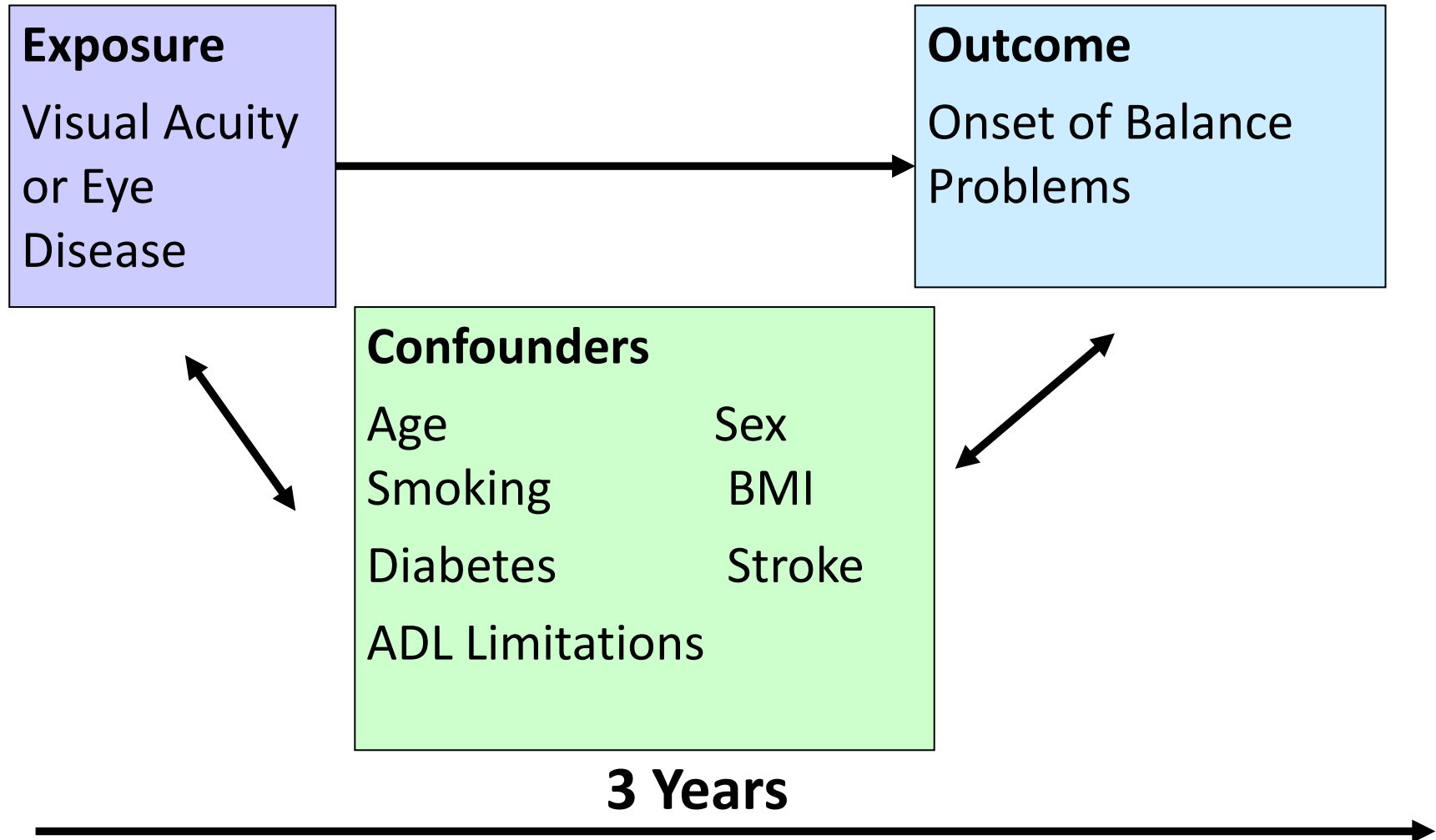
Gaps in Literature

- Very few longitudinal studies
- Some studies had small sample sizes
- Many eye disease studies did not have a comparison group with normal vision
- No studies found on cataract although some on cataract surgery and simulated cataract

Objectives

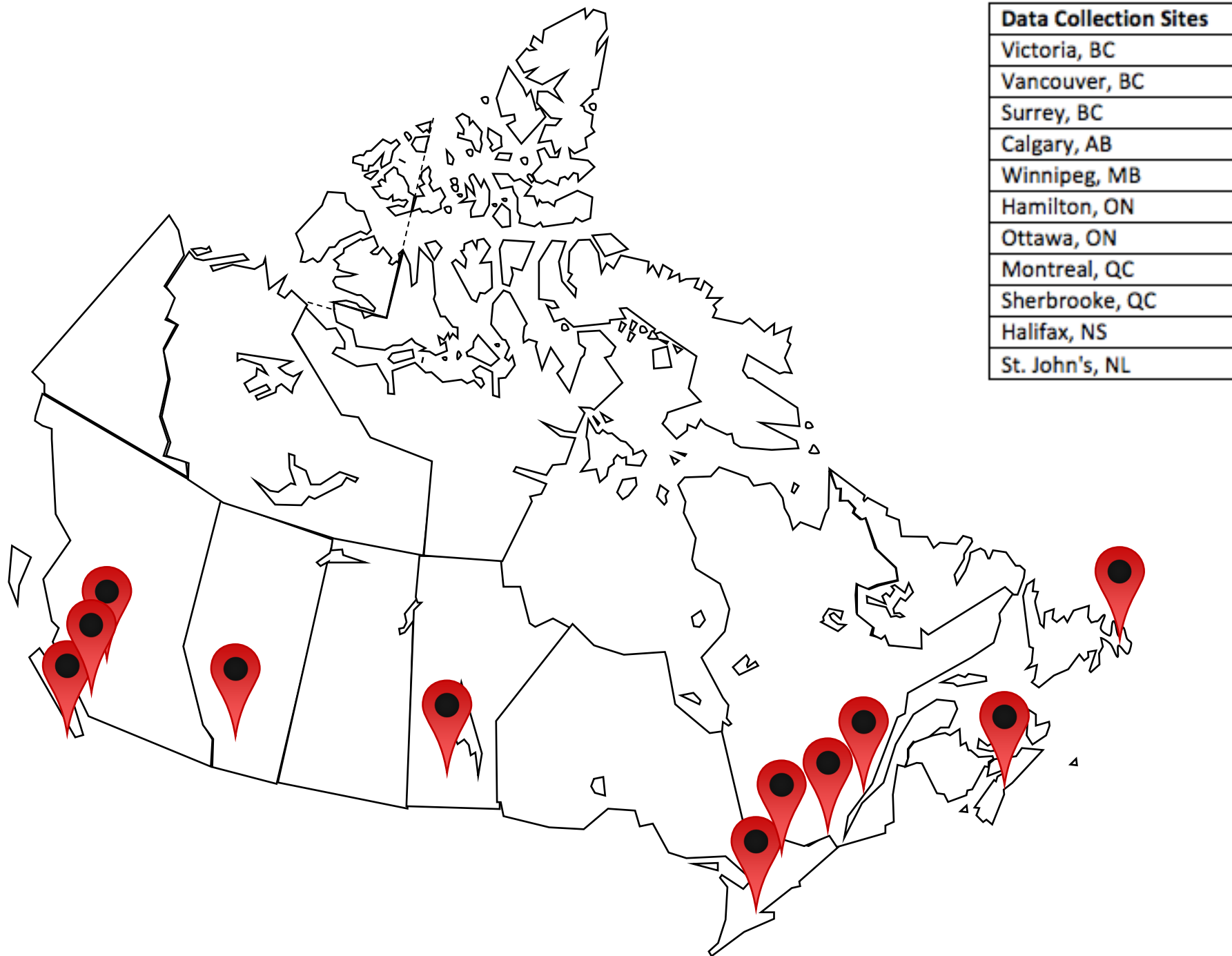
1. Examine the relationship between visual acuity and the onset of balance problems
2. Examine the relationship between eye disease and the onset of balance problems

Conceptual Framework



Methods

- CLSA Comprehensive Cohort included 30,097 adults ages 45-85 from 11 sites in 7 provinces
 - Visual acuity was measured in the Comprehensive Cohort
 - Baseline data were collected between 2012-2015 and follow-up data between 2015-2018
- People were excluded from the CLSA if they were in an institution, living on a First Nations reserve or settlement, were a full-time member of the Canadian Armed Forces, did not speak French or English, or had obvious cognitive impairment



Methods

- People were randomly sampled using provincial health registries and random digit dialing
- Stratified sampling was used to ensure adequate representation of various demographic groups

Methods

- Visual acuity was measured binocularly and monocularly using the ETDRS letter chart at 2 meters
- Participants wore their normal corrective lenses for distance
- Scores were converted to logMAR

0=20/20 vision

1=20/200 vision

1 line=0.1 logMAR



Methods

- Participants were asked if a doctor had ever diagnosed them with the following:
 - Cataract
 - Glaucoma
 - Macular degeneration
- If cataract was reported, participants were asked if they currently had a cataract
 - Those who reported no were assumed to have had cataract surgery

Methods



- One legged stand test
 - Good reliability (Giorgetti et al, 1998; Beauchamp, 2021)
 - Predictive of injurious falls (Vellas et al, 1997) and incident disability (Michikawa et al, 2009)
- Procedures
 - Excluded if unable to stand unassisted or use of cane/walker
 - Remove shoes, stand 1 m from wall, raise right leg to calf of left leg with hands on waist; repeat with other leg
 - Timer stopped at 60 seconds or when person lost balance or touched wall
 - Better time used in analysis

Methods

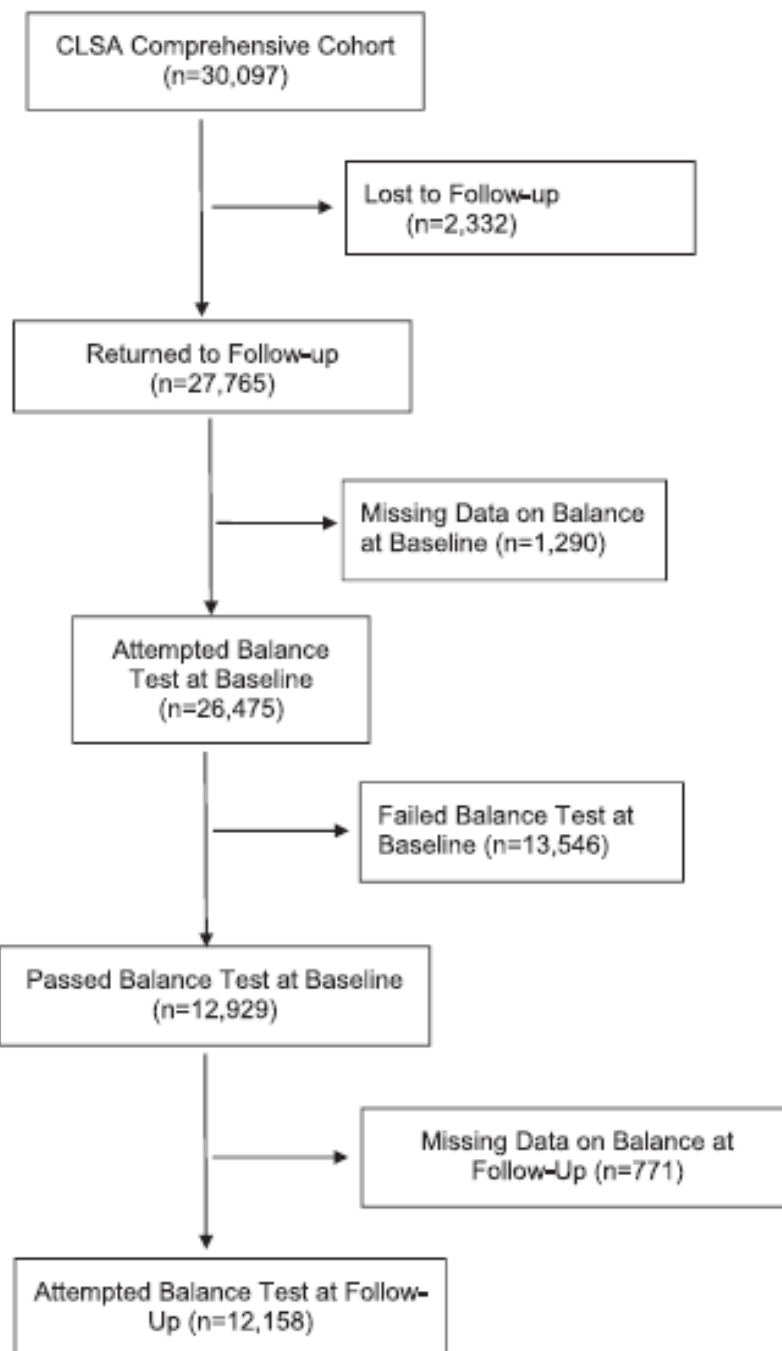
- Demographics
 - Age
 - Sex
 - Education
 - Province
- Lifestyle
 - Smoking

Methods

- Body Mass Index
 - Height and weight were measured
 - kg/m^2
 - Categorized to assess non-linearity with normal weight as the reference (20-24 kg/m^2)
- Health
 - Self-report of stroke or diabetes
 - ADL limitations (yes, no): any activities that could only be done with help or not at all (e.g. getting dressed, eating, walking, getting out of bed)

Methods

- Those who failed balance test at baseline were excluded
- Outcome: Failed (could not stand 60 seconds),
Did not Fail
 - Sensitivity analysis using 30 seconds
- Logistic regression was used
- The complex study design was accounted for in all analyses using SVY commands in Stata SE Version 16



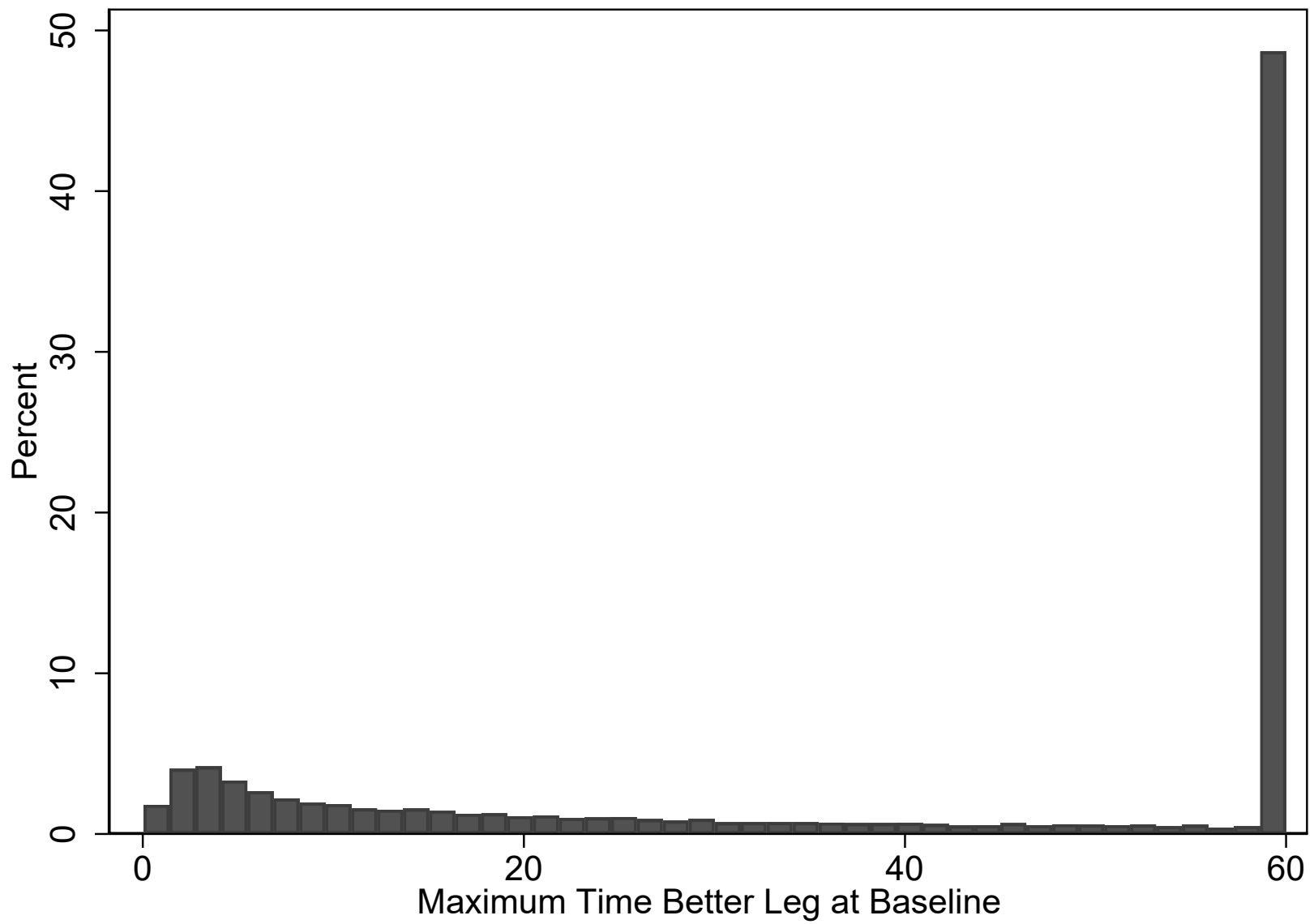


Table 1: In Analytical Sample

	In Analytical Sample n=12,158	Not In Analytical Sample n=17,939
Age, Years	55 (6)*	64 (11)
Obese	20%†	38%
Type 2 Diabetes	4%	12%
ADL Limitations	3%	13%
Visual acuity, logMAR	-0.02 (0.12)	0.05 (0.17)
Current cataract	3%	7%
AMD	2%	5%
Glaucoma	2%	6%

*Mean (SD); †Column percentage

Table 2: Failed Balance Test

	Passed Balance Test n=9,528 (78%)	Failed Balance Test n=2,630 (22%)
Age, Years	54 (6)*	59 (9)
Body Mass Index		
<20 kg/m ²	3%†	3%
20-24	37%	26%
25-29	42%	42%
≥30	18%	29%
Type 2 Diabetes	3%	7%
ADL Limitations	2%	5%
Stroke	0.4%	1.0%

*Mean (SD); †Column percentage

'Failed Balance Test' by 'Age Group'

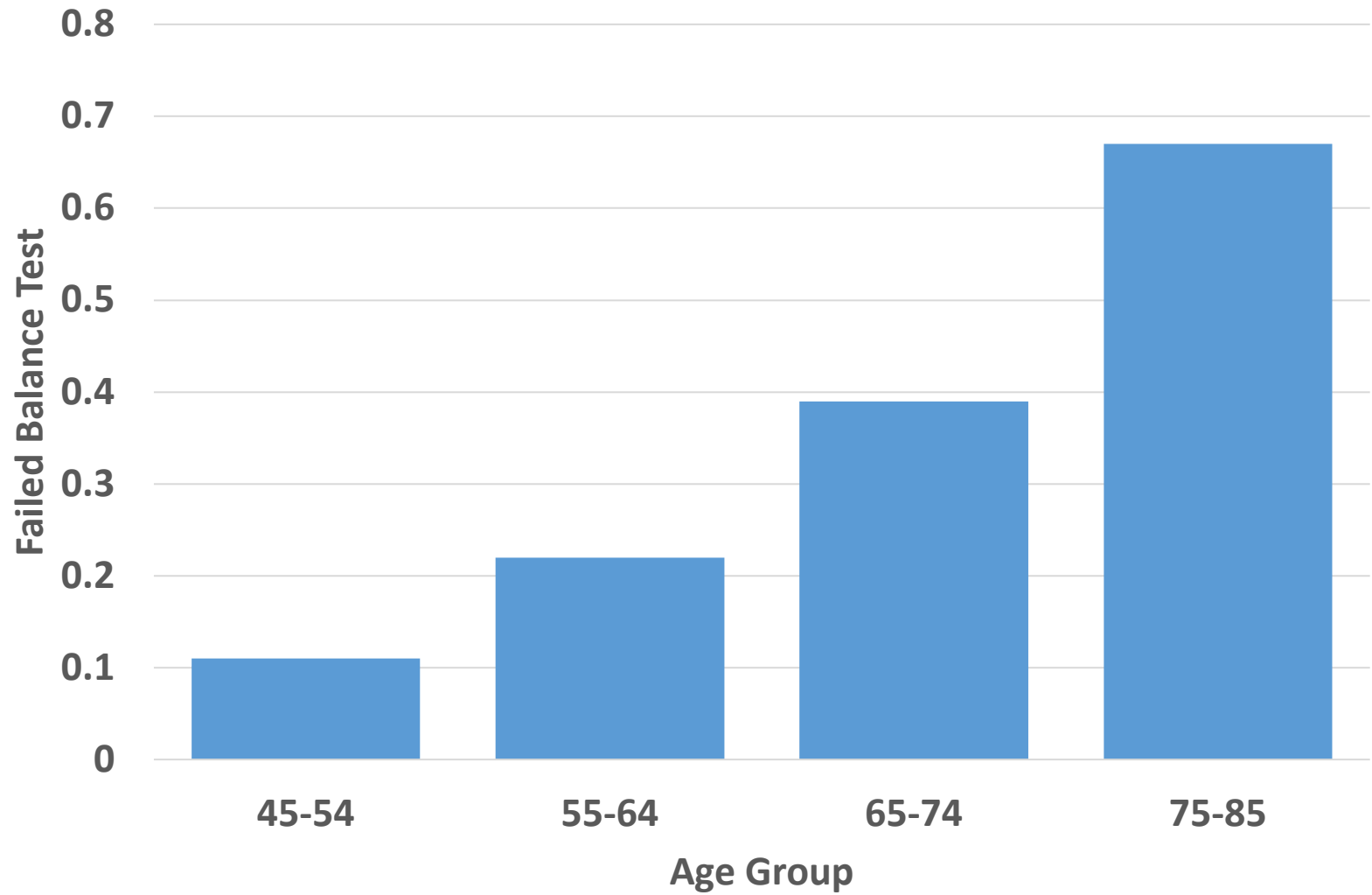


Table 3: Failed Balance Test

	Passed Balance Test n=9,528	Failed Balance Test n=2,630	P-Value
Visual acuity, logMAR	-0.03 (0.13)	0.02 (0.16)	<0.001
Cataract			<0.001
No	92%	82%	
Past	1%	3%	
Current	2%	5%	
Unknown	4%	10%	
AMD	1%	2%	<0.001
Glaucoma	2%	3%	<0.001

*Mean (SD); †Column percentage

Table 4: Visual Acuity Regression Model

	Failed Balance Test at Follow-up	
	OR	95% CI
Visual Acuity, per 1 line	1.15	1.10, 1.20

Adjusted for age, sex, BMI, smoking, diabetes, stroke, ADL limitations, province



Baseline Exposures	Failed Balance Test at Follow-up N = 11,973 Adjusted OR ^a	95% CI
Visual acuity, per 1 line	1.15	1.10, 1.20
Age, per year	1.11	1.10, 1.12
Sex		
Male	1.00	
Female	1.20	1.08, 1.34
Smoking		
Never	1.00	
Former	1.05	0.94, 1.17
Current	2.04	1.67, 2.50
Body mass index		
<20 kg/m ²	1.08	0.79, 1.48
20-24 kg/m ²	1.00	
25-29 kg/m ²	1.51	1.32, 1.71
≥30 kg/m ²	2.98	2.56, 3.48
Diabetes		
No	1.00	
Type 1	3.82	1.72, 8.47
Type 2	1.64	1.31, 2.06
Neither/suspect	1.22	0.99, 1.51
ADL limitations		
No	1.00	
Yes	2.01	1.53, 2.64

Table 5: Cataract Regression Model

	Failed Balance Test at Follow-up	
	OR	95% CI
Cataract		
None	1.00	reference
Cataract Was Removed	1.59	1.17, 2.16
Cataract Still in Eye	1.31	1.01, 1.68
Cataract – Status Unknown	1.08	0.90, 1.30

Adjusted for age, sex, BMI, smoking, diabetes, stroke, ADL limitations, province

Table 6: AMD Regression Model

	Failed Balance Test at Follow-up	
	OR	95% CI
AMD		
None	1.00	reference
AMD	1.05	0.73, 1.50

Adjusted for age, sex, BMI, smoking, diabetes, stroke, ADL limitations,
province

Table 7: Glaucoma Regression Model

	Failed Balance Test at Follow-up	
	OR	95% CI
Glaucoma		
None	1.00	reference
Glaucoma	1.17	0.87, 1.58

Adjusted for age, sex, BMI, smoking, diabetes, stroke, ADL limitations,
province

Sensitivity Analysis

- Results were essentially the same when using a 30-second cutoff
- Cataract surgery remained associated with balance after adjusting for visual acuity but current cataract did not
- Cataract surgery remained associated with balance after adjusting for AMD and glaucoma

Discussion

- Visual acuity was associated with failing the balance test at follow-up
 - In agreement with several cross-sectional studies and the Ostfield longitudinal study
 - A large proportion of visual acuity loss is easily treatable

Discussion

- Why was there an elevated odds ratio for cataract surgery?
 - In between first and second-eye cataract surgery?
 - Post-operative uncorrected refractive error?
 - Other ocular disease?
 - Other health-related differences?
 - Misclassification?
 - Worse vestibular balance after vision loss? (Ramulu, 2013)
- Need to confirm cataract surgery with health administrative data

Discussion

- Consistent with Meuleners et al (2014)
 - Retrospective cohort study using Australian health administrative data
 - Risk of an injurious fall requiring hospitalization doubled between first and second eye cataract surgery compared with the 2 years before first-eye surgery
 - 34% increase in risk of injurious falls requiring hospitalization after second eye cataract surgery

Discussion

- Not in agreement with
 - Harwood randomized clinical trial (2005): reduced risk of second fall
 - McGwin et al (2006): no association with self-report of falls or balance problems
 - Schwartz et al (2005): postural stability improved after cataract surgery when viewing with the surgical eye only
- Cataract surgery is a very safe and effective surgery. However, it is important to further investigate our finding

Discussion

- Interventions to improve balance could be suggested to people with vision loss
 - Exercise (e.g. Tai Chi, yoga, strength) (Lesinski, 2015)



Strengths

- Longitudinal study design with 3 years of follow-up
- Very large, population-based sample
- Measured visual acuity
- Measured balance

Limitations

- No full ophthalmological exam or access to medical records so disease status was based on self-report
- Only visual acuity was measured so no data on contrast sensitivity or visual field
- Data on cataract was at person-level rather than eye-level and many people did not know if they still had a cataract

Clinical Significance

- More attention needs to be paid to potential balance problems in older adults with vision loss
- Interventions to improve balance in those with vision loss should be considered

➤ [Am J Ophthalmol](#). 2021 Nov;231:170-178. doi: 10.1016/j.ajo.2021.06.008. Epub 2021 Jun 23.

Vision, Eye Disease, and the Onset of Balance Problems: The Canadian Longitudinal Study on Aging

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