2016, 1,500,000 Canadian males 45–85 years of age had at least mild hearing loss, 1,800,000 had at least mild vision loss, and 570,000 had both. Among females, 1,200,000 had at least mild hearing loss, 2,200,000 had at least mild vision loss, and 450,000 had both (Mick et al., 2020). It has been estimated that HI and vision impairment (VI), respectively, are the second- and third-most common impairments worldwide (Vos, 2016).

HI and VI in older adults are particularly important to understand given their influence on multiple health-related outcomes. For example, HI is associated with poor self-rated health (Choi et al., 2015) and difficulties with activities of daily living (ADLs) and instrumental ADLs (IADLs) (Chen et al., 2015; Choi et al., 2015; Slaughter, Hopper, Ickert, & Erin, 2014), falls (Campos, Ramkhalawansingh, & Pichora-Fuller, 2018; Jiam, Li, & Agrawal, 2016; Lin & Ferrucci, 2012), and is the top potentially modifiable risk factor for dementia (Davies, Cadar, Herbert, Orrell, & Steptoe, 2017; Deal et al., 2017; Fritze et al., 2016). HI is also associated with lower social support and loneliness (Mick, Parfyonov, Wittich, Phillips, & Pichora-Fuller, 2018).

Similarly, VI is associated with an increased risk of mortality (Reuben, Mui, Damesyn, Moore, & Greendale, 1999; Wang, Mitchell, Simpson, Cumming, & Smith, 2001), difficulties with ADLs and IADLs (Grue et al., 2009; Reuben et al., 1999), and difficulties caused by reduced mobility (Wang, Mitchell, Smith, Cumming, & Attebo, 1999). Individuals with VI also have lower social support, increased loneliness, reduced social participation, and smaller social networks (Grue et al., 2009; Laliberte Rudman et al., 2016). Compared with those who have no VI, they are also more likely to receive community-based supports such as home care and meals-on-wheels (Wang et al., 1999).

Older people with a combination of VI and HI, known as dual sensory impairment (DSI), are a particularly vulnerable group (Simcock, 2017; Simcock & Wittich, 2019; Wittich & Simcock, 2019). They experience limitations in completing ADLs and IADLs (Smith, Bennett, & Wilson, 2008), are at increased risk for depression (Capella-McDonnall, 2009; Fletcher & Guthrie, 2013; Guthrie, Theriault, & Davidson, 2015; Schneider et al., 2011) and mortality (Reuben et al., 1999), have significantly impaired communication function (McDonnall, Crudden, LeJeune, Steverson, & O'Donnell, 2016) and have reduced social participation (Mick et al., 2018). Despite these findings, there is very limited research globally on older adults with DSI (Heine & Browning, 2015), and this is also true in Canada (Guthrie et al., 2015; Wittich, Watanabe, & Gagné, 2011).

Previous research in Canada points to differential outcomes for individuals with VI, HI, or DSI. For example, in cross-sectional analyses, individuals with DSI and cognitive challenges were the most likely to experience communication difficulties, deterioration in communication over time, or a diagnosis of Alzheimer's dementia, and to have a primary caregiver feeling distressed (Guthrie et al., 2018). HI has also been shown to interact with impaired cognitive functioning to influence the risk of admission to long-term care. Individuals with an HI, but no cognitive challenges, had a faster time to admission versus clients with *both* HI and cognitive difficulties (Williams et al., 2020). Home care clients who experienced significant deterioration in their hearing are more likely than those with no changes in their hearing to experience communication difficulties and to have a caregiver who is distressed (Williams, Guthrie, Davidson, Fisher, & Griffith, 2018).

The current literature linking sensory impairments and outcomes such as communication difficulties, cognitive decline, and caregiver burden has several gaps. The research designs have been mainly cross-sectional, few studies have included adults with DSI,

and little research has been completed in Canada. Previous studies have primarily investigated community-dwelling older adults (Alattar et al., 2020; Amieva et al., 2015; Davies et al., 2017; Deal et al., 2017; Lin et al., 2013) or long-term care residents (Yamada et al., 2014), with very few focused on home care recipients (Vengnes Grue et al., 2009).

Home care is an important sector to study for several reasons. Roughly 2,000,000 Canadians receive home care annually, of whom approximately 40 per cent are 65 years of age and older (Sinha & Bleakney, 2014). The federal, provincial, and territorial governments recently endorsed A Common Statement of Principles on Shared Health Priorities, accompanied by an $11 billion federal investment to improve Canadians' access to home and community care (Government of Canada, 2019). Evidence to better understand this sector is important, because the majority of older adults prefer to "age in place" and remain in their own homes for as long as possible (Wiles, Leibing, Guberman, Reeve, & Allen, 2012). Finally, older persons receiving home care are typically more impaired in their cognitive and physical functioning than community-dwelling older adults. The prevalence of cognitive difficulties is approximately 20–30 per cent (de Almeida Mello et al., 2020; Garms-Homolova et al., 2017; Guthrie et al., 2018) in home care and roughly 3 per cent among physically healthy, community-dwelling older persons (Mery, Wodchis, & Laporte, 2016). The same is true for functional abilities, with prevalence of ADL impairment as high as 32 per cent in home care (Brown, McAvay, Raue, Moses, & Bruce, 2003; Foebel et al., 2015) versus roughly 10 per cent among those living in the community (Mery et al., 2016; Raina, Wolfson, Kirkland, & Griffith, 2010–2015). This group is important to study because they are under-represented in health services research in Canada.

The present study aimed to address several of the gaps in the current literature. A longitudinal design was utilized to enable the identification of the onset of new sensory impairments. Assessing home care clients over time allowed for an evaluation of risk versus simply understanding cross-sectional relationships. We created multiple unique cohorts to explore how the identification of the onset of new sensory impairments influences the risk of several important outcomes including communication difficulties, a deterioration in cognitive performance, and the risk of caregiver burden. We chose to focus on individuals with a newly identified sensory impairment, because this group may be in an adjustment phase and may not have had time to develop compensatory strategies (e.g., seeking advice and looking into and purchasing assistive devices), whereas people with longer-term impairments may have had time to do so. Developing these compensatory strategies may also be more difficult among home care recipients who are also dealing with multiple co-morbidities.

Based on our previous work and other literature, we anticipated that older adults with a newly identified DSI would show a greater risk for multiple negative outcomes than individuals with VI or HI only. For example, we expected that this group would be more likely to experience communication difficulties, worsening cognitive performance, and caregiver burden, even after adjusting for multiple control variables.

Design and Methods

Data Source

We conducted secondary analyses of data collected using the Resident Assessment Instrument for Home Care (RAI-HC) in

Table 1. Summary of the seven different cohorts and their status at baseline and at follow-up

Status at Baseline Assessment (Time 1)	Status at Follow-up Assessment (Time 2)
Cohort 1: No sensory impairment	
• No HI and no VI at Time 1 (*n* = 47,475)	• No HI no VI at Time 2 • Mean time between assessments = 9.2 months (SD = 7.9)
Cohort 2: New HI only	
• No HI and no VI at Time 1 (*n* = 12,771)	• New HI only at Time 2 • Mean time between assessments: 11.0 months (SD = 9.1)
Cohort 3: New VI only	
• No HI and no VI at Time 1 (*n* = 7,485)	• New VI only at Time 2 • Mean time between assessments: 10.6 months (SD = 8.4)
Cohort 4: Persistent DSI	
• HI and VI at Time 1 (*n* = 22,148)	• HI and VI at Time 2 • Mean time between assessments: 7.7 months (SD = 6.3)
Cohort 5: New VI in the presence of existing HI	
• Existing HI and no VI at Time 1 (*n* = 9,087)	• Existing HI and new VI at Time 2 • Mean time between assessments: 9.7 months (SD = 7.8)
Cohort 6: New HI in the presence of existing VI	
• Existing VI and no HI at Time 1 (*n* = 4,683)	• Existing VI and new HI at Time 2 • Mean time between assessments: 9.9 months (SD = 7.7)
Cohort 7: New DSI	
• No HI and no VI at Time 1 (*n* = 3,271)	• New HI and new VI at Time 2 • Mean time between assessments: 12.8 months (SD = 10.7)

Note. HI = hearing impairment; VI = vision impairment; DSI = dual sensory impairment; SD = standard deviation

Ontario. All data included in this article came from the RAI-HC, and no other supplementary assessments or data were used. The RAI-HC is a standardized assessment that is routinely used to assess clients who are expected to receive at least 60 days of service (Ontario Ministry of Health and Long-Term Care, 2007). The assessment has established validity and reliability and includes roughly 300 items to capture domains including, but not limited to communication, sensory impairments, cognitive status, and functional ability (Hirdes et al., 2008). Assessments are completed by trained care coordinators (typically registered nurses) through an interview with the client and their informal caregivers, and in consultation with other health professionals, as needed. Re-assessments are completed every 6–12 months or following a clinically important change in health status. Because the assessment is mandated in Ontario, the software used to capture the completed assessments does not allow the assessor to leave fields blank. Therefore, there are virtually no missing data in this data set. In Ontario, all assessments are shared with the Canadian Institute for Health Information (CIHI). Researchers can apply to the CIHI for a copy of the anonymized data, as was done for the present study. The Research Ethics Board at Wilfrid Laurier University reviewed and approved the design of this study (REB #4184).

Sample

The sample included all home care clients who were 65 years of age and older and who had completed at least two RAI-HC assessments between 2009 and 2014 (*n* = 106,920). Each pair of assessments that was completed within 60 months was examined to find the first point in time when a sensory impairment was newly identified for a client. The time frame between assessments was chosen in order to maximize the length of follow-up within the data set. For example,

if an individual had three assessments, and at their first assessment had no sensory impairment, but were identified as having a new HI at their third assessment (i.e., no new impairment at their second), then their third assessment would be considered T2 and their second assessment would be considered T1. We followed each person forward to the first instance when a new sensory impairment occurred, which was deemed their T2 assessment, whereas the assessment just previous to this one was T1. For those who did not develop a new impairment at any of their assessments, we used their two most recent assessments in the database as T1 and T2.

We defined seven mutually exclusive cohorts of individuals based on their sensory status at baseline (T1) and how this status may have changed by follow-up (T2) (Table 1). The seven cohorts included those with (1) no sensory impairments at either T1 or T2 (*n* = 47,475), (2) a newly identified HI at T2 (*n* = 12,771), (3) a newly identified VI at T2 (*n* = 7,485), (4) "persistent" DSI that was present at both T1 and T2 (*n* = 22,148), (5) an existing HI and a newly identified VI at T2 (*n* = 9,087), (6) an existing VI and a newly identified HI at T2 (*n* = 4,683), and (7) no baseline impairments and a newly identified DSI at T2 (*n* = 3,271).

Sensory Measures

Care coordinators complete the RAI-HC based on a standardized manual developed by interRAI, the group who holds the copyright for the instrument (Morris et al., 1999). They determine a client's hearing and vision status based on a combination of self-assessment, discussions with caregivers, consultations with other care providers, and review of any available medical records, as appropriate. For the measures related to vision and hearing (one item each on the RAI-HC), assessors are instructed to evaluate sensory impairments when the client

is using their existing aids or devices (i.e., while using hearing aids or glasses).

The presence of HI was defined as a score of one or higher on a single item on the RAI-HC. This item scores hearing ability from zero (no impairment) to three (highly impaired). Similarly, VI was defined as a score of one or higher on a single item that scores vision from zero (no impairment) to four (severely impaired). Finally, DSI was defined as a score of three or higher on the Deafblind Severity Index (DbSI). The DbSI uses the two items that measure vision and hearing to identify clients with at least minimal losses in both senses (i.e., a score of one or higher on both items) (Dalby et al., 2009). The hearing and vision items have good test–retest reliability (hearing: κ = 0.83; vision: κ = 0.85) (Dalby et al., 2009) and correlate well with gold standard objective measures (Urqueta Alfaro et al., 2019).

Outcome Measures

The RAI-HC includes two items on communication, one to capture expressive and the other to capture receptive communication. The first item, on expressive communication, scores the person's ability to express themselves orally, using sign language, in writing, or some combination of these techniques. The other item targets the person's capacity to understand information communicated with the person orally, in writing, through sign language, or in braille. In both cases, the items are scored from zero to four, where a score of one or higher was used to define difficulties with communication. A deterioration in communication was defined as at least a one-point increase on the item over time.

The Caregiver Risk Evaluation (CaRE) algorithm is a decision-support tool that differentiates the risk of caregiver burden among informal caregivers (Guthrie et al., 2021). The algorithm is created using items from within the RAI-HC and assigns caregivers to one of four unique groups, ranging from low risk (score of zero) to very high risk (score of four) of experiencing burden. Individuals were grouped into two categories, including those with low or moderate risk (scores of 1 and 2; roughly 60% of individuals across the seven cohorts) and compared with those with a high or very high risk of experiencing caregiver burden (scores of 3 and 4; roughly 40%).

The Cognitive Performance Scale (CPS) is a hierarchical scale which includes two items found on traditional cognitive assessments (e.g., short-term memory, daily decision making) and two items reflecting functional status (e.g., expressive communication, independence in eating). The scale ranges from zero to six (0 = no cognitive impairment, 1 = borderline intact, 2 = mild impairment, 3 = moderate impairment, 4 = moderately severe impairment, 5 = severe impairment, and 6 = very severe impairment), has excellent inter-rater reliability (average κ = 0.85), and is correlated with performance on two cognitive screening measures; namely, the Montreal Cognitive Assessment (Jones, Perlman, Hirdes, & Scott, 2010) and the Mini Mental State Exam (Gruber-Baldini, Zimmerman, Mortimore, & Magaziner, 2000). It was designed to be a functional measure and to act as a brief screen for impaired cognitive performance.

We focused on four main dependent measures; namely, a deterioration in: (1) cognitive performance (measured with the CPS scale), (2) receptive communication, (3) expressive communication, and (4) the CaRE algorithm. In all cases, a minimum of a one-point change on the item or scale was considered to be a meaningful decline. These four outcomes were chosen because they are highly relevant to the functioning of individuals who are experiencing sensory changes over time. Furthermore, they

enabled us to build upon our earlier cross-sectional analyses which showed associations among these outcomes(Guthrie et al., 2018).

Control Variables

There are five health index scales embedded within the RAI-HC. For all scales, a higher score indicates worse functioning (i.e., greater impairment). The scales have been described in detail previously (Guthrie et al., 2018) and are summarized.here.

1. The Activities of Daily Living (ADL) Self-Performance Hierarchy Scale (ADL-H) includes items on bathing and dressing with scores ranging from a score of zero (independent) to six (total dependence) (Morris, Fries, & Morris, 1999). A score of two or higher, representing the point at which an individual can no longer complete all of their ADLs independently, was used to define moderate/severe ADL impairment, in line with previous research (Davidson & Guthrie, 2017; Guthrie et al., 2018; Williams, Jamal, & Guthrie, 2018).

2. The Instrumental Activities of Daily Living (IADL) Involvement Scale has scores ranging from 0 to 21 and includes items on telephone use, managing medications, and meal preparation. A cut-point of 14 or higher was used to indicate at least moderate impairment in performing these tasks, in line with previous studies (Guthrie et al., 2018; Williams, Jamal, & Guthrie, 2018).

3. The Depression Rating Scale (DRS) is a summative scale with scores ranging from 0 to 14. A score of three or higher, the cut-point we have chosen, is predictive of a clinical diagnosis of depression (Martin et al., 2008).

4. The Pain Scale includes two items which capture the frequency and intensity of pain. The scale ranges from zero to four and has been validated against the vertical version of the Visual Analog Scale (VAS). A score of two or higher was used to indicate severe/daily pain, because research has shown an important increase in the VAS score among those with a score of two or higher (Fries, Simon, Morris, Flodstrom, & Bookstein, 2001).

5. The Changes in Health, End-Stage Disease and Signs and Symptoms (CHESS) Scale is scored from zero to five and is a measure of health instability. For every one-point increase on the scale, there is a nearly two-fold increased risk of mortality. A cut-point of two or higher was used to determine health instability based on previous research showing a marked increase in the hazard ratio for mortality among those scoring two or higher compared with those scoring less than two (Hirdes, Poss, Mitchell, Korngut, & Heckman, 2014).

Several other dichotomous variables (measured as yes/no) were examined, including self-reported loneliness, and items related to diagnoses (Alzheimer's dementia/another type of dementia, stroke, diabetes, hypertension, coronary artery disease, congestive heart failure, Parkinson's disease, irregularly irregular pulse, peripheral vascular disease, cataracts, and glaucoma). A co-morbidity count was developed (having at least one diagnosis vs. none) from the preceding list.

Univariate Analysis

The preliminary descriptive analysis examined the absolute percent change between T1 and T2 across multiple outcomes and across the seven cohorts. We focused on change over time, as we have previously explored similar outcomes, but using cross-sectional data (Guthrie et al., 2018). Given the large sample size and potential for type I error, we used an absolute standardized difference (stdiff, similar to a z-score) of 0.2 or higher to identify statistically

Table 2. *Continued*

	Cohort 1: No Sensory Impairments (n = 47,475)	Cohort 2: New HI Only (n = 12,771)	Cohort 3: New VI Only (n = 7,485)	Cohort 4: Persistent DSI (n = 22,148)	Cohort 5: Existing HI, New VI (n = 9,087)	Cohort 6: Existing VI, new HI (n = 4,683)	Cohort 7: New DSI (n = 3,271)
	% (n)						
Severe/daily pain (2-4)	51.8 (24,589)	53.9 (6,884)	55.5 (4,158)	56.3 (12,479)	57.7 (5,247)	56.4 (2,642)	54.4 (1,779)
Changes in Health, End-Stage Disease and Signs and Symptoms (CHESS) Scale							
Mild/moderate health instability (0-1)	59.8 (28,411)	62.2 (8,204)	62.8 (4,701)	51.5 (11,412)	57.7 (5,242)	61.5 (2,878)	63.8 (2,087)
Severe health instability (2-5)	40.2 (19,064)	35.8 (4,567)	37.2 (2,784)	48.5 (10,736)	42.3 (3,845)	38.5 (1,805)	36.2 (1,184)
Cognitive Performance Scale							
Intact (0)	39.2 (18,614)	42.0 (5,355)	39.9 (2,983)	15.6 (3,445)	27.2 (2,468)	32.4 (1,517)	40.6 (1,327)
Borderline intact (1)	15.4 (7,328)	18.7 (2,389)	18.4 (1,375)	15.6 (3,451)	19.4 (1,758)	20.2 (943)	19.5 (636)
Mild impairment (2)	31.0 (14,722)	31.2 (3,981)	30.3 (2,268)	47.0 (10,410)	41.8 (3,788)	35.9 (1,681)	30.5 (996)
Moderate impairment (3)	9.0 (4,266)	5.7 (726)	6.8 (506)	12.1 (2,688)	7.6 (690)	6.8 (317)	5.4 (175)
Moderate/severe impairment (4)	1.1 (540)	0.6 (70)	0.9 (68)	2.2 (491)	1.1 (95)	1.0 (48)	0.9 (30)
Severe impairment (5)	3.8 (1,817)	1.8 (226)	3.3 (245)	5.9 (1,313)	2.8 (250)	2.7 (127)	2.6 (85)
Very severe impairment (6)	0.4 (182)	0.1 (16)	0.5 (35)	1.6 (347)	0.3 (24)	0.9 (42)	0.5 (16)
Other measures							
Caregiver Risk Evaluation (CaRE)							
Low/moderate risk (1-2)	61.2 (29,034)	65.6 (8,367)	61.2 (4,580)	50.5 (11,172)	60.6 (5,499)	59.1 (2,767)	64.4 (2,105)
High/very high risk (3-4)	38.8 (18,421)	34.4 (4,397)	38.8 (2,904)	49.5 (10,940)	39.4 (3,580)	40.9 (1,915)	35.6 (1,165)
Difficulties with expressive communication	25.3 (12,013)	19.6 (2,508)	23.1 (1,732)	51.4 (11,373)	35.9 (3,259)	27.1 (1,269)	21.3 (695)
Difficulties with receptive communication	24.2 (11,491)	19.7 (2,521)	20.9 (1,565)	59.3 (13,121)	43.5 (3,956)	26.2 (1,226)	21.6 (705)
Self-reported loneliness	12.0 (5,714)	12.3 (1,574)	13.8 (1,032)	17.0 (3,769)	14.6 (1,326)	16.6 (775)	13.0 (425)
Disease Diagnoses							
Alzheimer's dementia/other dementia	28.7 (13,609)	23.3 (2,964)	24.2 (1,809)	31.0 (6,871)	24.9 (2,257)	21.9 (1,017)	22.2 (719)
Stroke	15.4 (7,323)	15.7 (2,002)	18.0 (6,141)	21.7 (4,795)	18.3 (1,662)	21.7 (1,015)	15.1 (493)
Diabetes	25.7 (12,215)	24.7 (3,154)	29.1 (2,181)	26.8 (5,929)	25.5 (2,317)	30.3 (1,420)	27.4 (895)
Parkinson's disease	4.8 (2,299)	4.3 (553)	6.8 (507)	5.4 (1,194)	5.6 (505)	5.8 (271)	5.0 (164)
Congestive heart failure	10.3 (4,885)	11.8 (1,507)	10.8 (808)	15.7 (3,481)	14.2 (1,286)	13.5 (633)	12.9 (421)
Coronary artery disease	23.2 (11,028)	25.0 (3,195)	23.9 (1,786)	28.9 (6,389)	28.7 (2,612)	25.7 (1,201)	26.4 (862)
Hypertension	60.2 (28,595)	61.8 (7,886)	61.9 (4,633)	65.9 (14,586)	64.9 (5,899)	64.2 (3,00)	61.9 (2,024)
Peripheral vascular disease	6.2 (2,928)	6.5 (827)	6.3 (468)	6.8 (1,811)	7.2 (658)	6.4 (300)	6.3 (207)
Irregularly irregular pulse	11.2 (5,336)	12.6 (1,614)	10.2 (760)	14.0 (3,109)	14.3 (1,298)	11.8 (553)	12.1 (394)
Glaucoma	5.1 (2,427)	5.5 (702)	8.6 (642)	15.2 (3,367)	9.6 (876)	15.6 (729)	7.4 (242)
Cataracts	10.1 (4,801)	10.5 (1,343)	14.9 (1,116)	20.8 (4,595)	15.6 (1,417)	21.0 (984)	13.7 (448)

Note. HI = hearing impairment; VI = vision impairment; DSI = dual sensory impairment.

Table 3. Percent of participants who experienced a change between baseline (T1) and onset of a new impairment (T2) across the seven cohorts[a]

	Cohort 1: No Sensory Impairments (*n* =47,475)	Cohort 2: New HI Only (*n* = 12,771)	Cohort 3: New VI Only (*n* = 7,485)	Cohort 4: Persistent DSI (*n* = 22,148)	Cohort 5: Existing HI, New VI (*n* = 9,087)	Cohort 6: Existing VI, New HI (*n* = 4,683)	Cohort 7: New DSI (*n* = 3,271)
			% change between T1 and T2				
Health index scales							
Activities of Daily Living (ADL) Self-Performance Hierarchy Scale							
Moderate/severe ADL impairment (2-6)	8.4	11.5	11.9	10.6	14.4	12.0	21.0[a]
Instrumental Activities of Daily Living (IADL) Involvement Scale							
Moderate/severe impairment (14-21)	8.9	14.2	12.6	8.3	15.2	12.5	22.8[a]
Depression Rating Scale (DRS)							
Signs and symptoms of depression (3-14)	2.8	5.9	7.4	3.0	7.7	5.6	12.1[a]
Pain Scale							
Severe/daily pain (2-4)	1.2	3.7	2.8	1.4	2.2	2.9	7.3[a]
Changes in Health, End-Stage Disease and Signs and Symptoms (CHESS) Scale							
Severe health instability (2-5)	3.7	11.9	10.2	4.2	11.7	12.4	22.3[a]
Cognitive Performance Scale							
Mild to moderate impairment (1-6)	6.7	16.2	13.6	4.6	12.2	14.9	23.9[a]
Other Measures							
Caregiver Risk Evaluation (CaRE)							
High/very high risk (3-4)	4.8	9.8	10.1	4.2	10.7	9.5	16.1[a]
Difficulties with expressive communication	6.3	16.4	11.0	6.2	15.2	19.0	28.2[a]
Difficulties with receptive communication	6.4	20.7	10.9	6.3	15.6	23.2	31.6[a]
Self-reported loneliness	1.0	3.0	3.7	0.3	3.1	2.9	5.6[a]
Disease diagnoses							
Alzheimer's dementia/other dementia	3.3	5.8	5.2	4.3	6.8	5.4	9.4[a]
Stroke	1.2	2.0	3.0	1.4	2.8	1.9	4.4
Diabetes	0.7	1.0	1.3	0.5	1.0	0.7	1.8
Parkinson's disease	0.4	0.5	0.7	0.4	0.6	0.7	0.7
Congestive heart failure	1.7	2.7	2.4	2.0	3.0	3.0	4.3
Coronary artery disease	2.0	3.5	3.0	1.8	2.9	2.9	3.9
Hypertension	2.5	3.6	3.8	2.0	2.7	3.2	4.2
Peripheral vascular disease	0.7	1.3	1.0	0.7	1.0	0.5	1.3
Irregularly irregular pulse	1.4	2.4	2.3	1.4	1.6	2.3	3.5
Glaucoma	0.5	0.8	1.8	0.9	1.8	1.3	2.2
Cataracts	0.2	0.5	5.2	0.0	3.5	0.5	3.9[a]
Co-morbidity count of ≥ 1 (at least one of the above-listed diagnoses)	1.8	2.6	3.6	1.4	2.1	1.7	4.7

Note. Negative values in the table indicate a *decrease* in the proportion in that group over time.
[a]Standardized difference between Cohort 1 and Cohort 7 of at least 0.2 (absolute value).HI = hearing impairment; VI = vision impairment; DSI = dual sensory impairment.
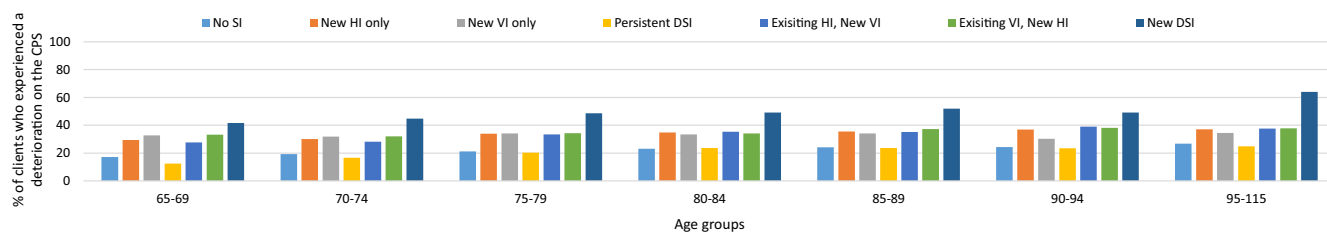
Figure 1. Individuals who experienced any deterioration on the Cognitive Performance Scale (CPS) (any one-point increase) between time 1 and time 2
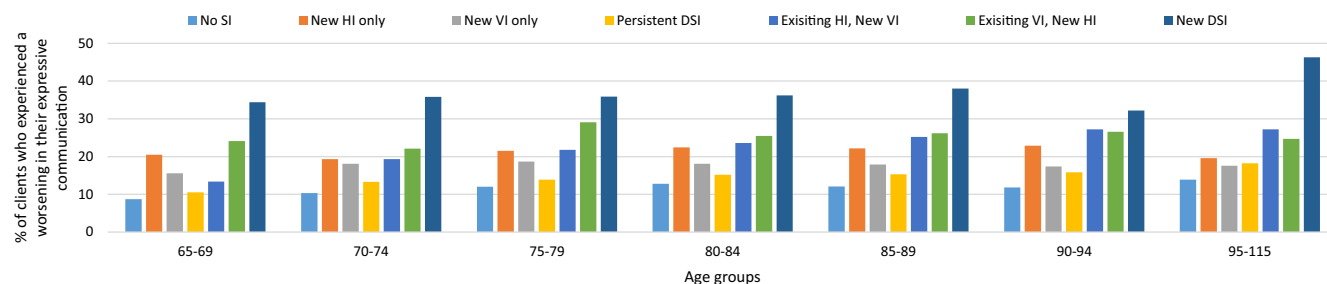
Figure 2. Comparison of the clients with and without sensory impairments who experienced a deterioration in expressive communication
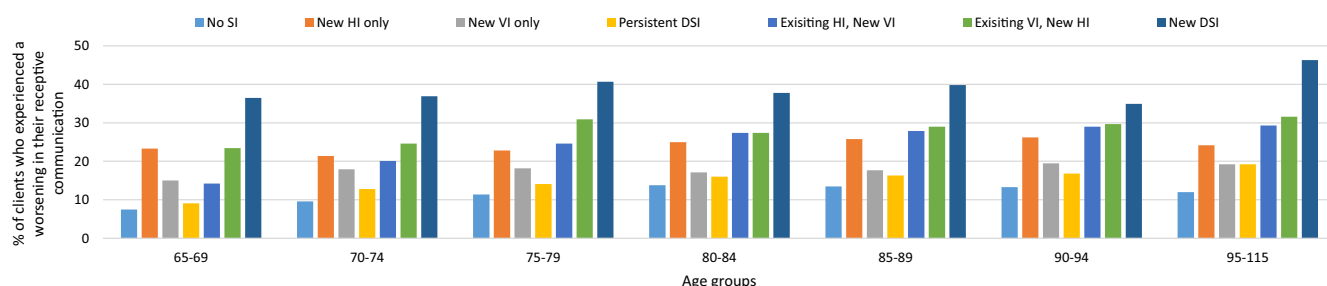
Figure 3. Comparison of clients with and without sensory impairments who experienced a deterioration in their receptive communication
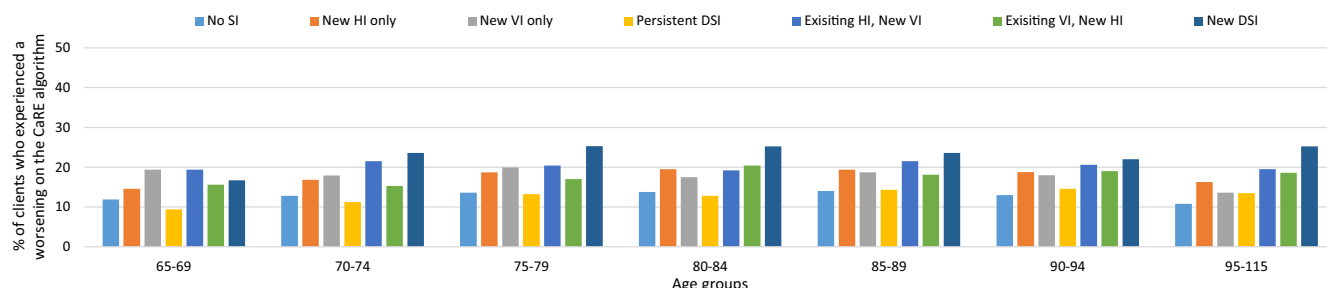
Figure 4. Comparison of clients with and without sensory impairments with a caregiver who experienced a deterioration on the Caregiver Risk Evaluation (CaRE) algorithm

a difference of 8.5 per cent (65–69 years of age: 16.7% vs. ≥ 95 years of age: 25.2%; Figure 4).

Given that there was an influence of age across several of these outcomes and given the known association among age, cognitive status, and sensory functioning, we explored these outcomes using multivariate regression. After adjusting for multiple control variables, individuals with a newly identified DSI (compared with those without DSI) were significantly more likely to experience each outcome. This was particularly true for both types of communication in which the newly identified DSI cohort had at least a four-fold increase in the odds of experiencing a decline in expressive

communication (odds ratio [OR] = 4.13; 95% confidence interval [CI]: 3.69, 4.62) as well as a decline in receptive communication (OR = 5.22; CI: 4.63, 5.87). The newly identified HI only cohort also had a significant increase in the odds of having communication difficulties, with a two-fold increase for a decline in receptive communication (OR = 2.61; CI: 2.43, 2.80), compared with those without a new HI. The odds were lower, but still significant, for difficulties with expressive communication (OR = 2.00; CI: 1.86, 2.15). Similar, but lower odds were also observed for the newly identified VI cohort for both a decline in receptive (OR = 1.53; CI: 1.39, 1.68) and expressive communication (OR = 1.52; CI: 1.39,

Table 4. Logistic regression models for the association between newly acquired sensory impairments and the odds of the event across four unique outcomes

Sensory Impairment Category	Decline in Receptive Communication	Decline in Expressive Communication	Decline on the Caregiver Burden (CaRE) Algorithm	Decline on the CPS score
	OR (95% CI)			
New hearing impairment only	2.61 (2.43, 2.80)	2.00 (1.86, 2.15)	1.43 (1.32, 1.53)	1.68 (1.59, 1.79)
Standard error	0.0361	0.0366	0.0376	0.0312
New vision impairment only	1.53 (1.39, 1.68)	1.52 (1.39, 1.67)	1.38 (1.26, 1.51)	1.65 (1.53, 1.78)
Standard error	0.0489	0.0474	0.0470	0.0383
New dual sensory impairment	5.22 (4.63, 5.87)	4.13 (3.69, 4.62)	1.81 (1.60, 2.06)	3.11 (2.80, 3.46)
Standard error	0.0604	0.0578	0.0486	0.0543

Note. All models were adjusted for age, sex, level of education, marital status, Depression Rating Scale (DRS) score of ≥ 3, co-morbidity (sum of disease diagnoses listed in Table 1) and Cognitive Performance Scale (CPS) score (only for decline in receptive communication outcome).
OR = odds ratio comparing those with the impairment to those without it; CI = confidence interval

1.67). The newly identified DSI cohort also had a roughly 80 per cent increase in the risk of caregiver burden (OR = 1.81; CI: 1.60, 2.06), compared with roughly 40 per cent in the newly identified HI cohort (OR = 1.43; CI: 1.32, 1.53) and newly identified VI cohorts (OR = 1.38; CI: 1.26, 1.51). Finally, the newly identified DSI cohort was approximately three times as likely to experience a worsening on the CPS score (OR = 3.11; CI: 2.80, 3.46), and again, the odds ratios were lower in the two other single-impairment cohorts (Table 4).

Overall, the newly identified DSI cohort stands out as being more likely to experience multiple negative outcomes related to declines in communication, worsening on the CPS score, and an increased risk of caregiver burden, even after adjusting for many other covariates that may be potential confounders in these associations.

Discussion

The goal of the present study was to describe how a new onset of sensory impairments may influence the risk of negative outcomes such as communication difficulties, changes in cognitive performance, and caregiver burden in a group of older home care clients. In this sample of roughly 100,000 older clients who were receiving home care, 35 per cent were newly identified as having a sensory impairment between the baseline assessment and a re-assessment. The average time frame between the two assessments was approximately 12 months. This is not a trivial proportion of older adults for whom sensory challenges emerge during the delivery of home care. To our knowledge, this is one of the first Canadian studies to explore the influence of single and dual sensory impairments on multiple health-related outcomes over time. The fact that these impairments took roughly a year to be identified implies that there is a window of opportunity within which to assess the person for changes in sensory functioning and to implement strategies and provide rehabilitative services to maximize their ability to function using their residual vision and hearing. This window of opportunity also applies to family caregivers. These caregivers also require access to supportive services and strategies to maintain their own well-being while helping their loved one with the emerging sensory impairments that could exacerbate many aspects of that person's health and wellness.

At baseline, clients with sensory impairments were more likely to experience functional impairment, health instability, to have difficulties in communication, and to experience cognitive challenges. This is in line with multiple longitudinal studies supporting HI as an important risk factor for the onset of cognitive impairment (Davies et al., 2017; Deal et al., 2017; Fischer et al., 2016; Fritze et al., 2016; Gurgel et al., 2014; Lin et al., 2011, 2013) or a deterioration in cognitive performance (Alattar et al., 2020; Amieva et al., 2015). A smaller number of studies likewise support VI as a risk factor for dementia or cognitive decline (Barnes et al., 2007; Reyes-Ortiz et al., 2005; Rogers & Langa, 2010; Zheng et al., 2018). A limited number of studies have been published that examine DSI as a factor for cognitive decline, and all reported a positive association (Lin et al., 2004; Liu, Cohen, Fillenbaum, Burchett, & Whitson, 2016; Maharani et al., 2018; Yamada et al., 2015).

Regardless of the sensory cohort, and irrespective of age, roughly 20 per cent of the home care clients in the present study had a worsening in their CPS score over time. The actual change in the proportion showing this deterioration (i.e., comparing the proportion at T1 with the proportion at T2) was relatively flat, except in the newly identified DSI cohort. Although this cohort represents a relatively small proportion of the sample (3%), it represents a sample of just over 3,200 unique individuals. To our knowledge, this is larger than in most recent publications, which tend to focus on more clinical and rehabilitation populations (Roets-Merken, Zuidema, Vernooij-Dassen, & Kempen, 2014; Roets-Merken et al., 2017; Schneider et al., 2014; Shakarchi et al., 2020; Urqueta Alfaro, Guthrie, McGraw, & Wittich, 2020).

Those in the new DSI cohort represent a uniquely impaired group of older adults. More so than any other cohort, they were significantly more likely to experience a deterioration in multiple areas, including communication, cognitive performance, functional abilities, and symptoms of depression. Even after adjusting for multiple control variables, this cohort had an increased risk across all four of the key outcomes measured, including the risk for caregiver burden. These results are in line with previous research showing individuals with DSI to be at increased risk of functional impairment (Smith et al., 2008), depression (Capella-McDonnall, 2009; Fletcher & Guthrie, 2013; Guthrie et al., 2015; Schneider et al., 2011) and communication difficulties (McDonnall et al., 2016). However, what we cannot tell from our data is exactly when the DSI was first evident, because we only know that it was identified within a specific time frame between two assessments. This is a limitation to our work, because we cannot differentiate individuals who had DSI caused by a single event (e.g., a stroke) from those for whom the onset was more gradual.

The consequences of newly identified sensory changes on caregiver burden is particularly noteworthy given the evidence that the degree of vision loss has been shown to be positively correlated with

the caregivers' perceived level of burden (Braich, Lal, Hollands, & Almeida, 2012; Khan et al., 2016). Three other studies also found a relationship between more severe vision loss and the risk of depression in the caregiver (Bambara et al., 2009; Braich et al., 2012, 2016). A single Canadian study, the only one we found looking at hearing loss, reported that higher caregiver burden was experienced by caregivers who cared for someone without HI than by caregivers of someone with difficulties in their hearing (Westaway, Wittich, & Overbury, 2010). The authors suggest that this finding may reflect the fact that all participants came from a rehabilitation centre, and participants with a hearing loss were all receiving rehabilitation services. The receipt of these services would likely have benefited both the individuals and their caregivers, thus reducing the level of stress or burden experienced by these caregivers. We did not find any research looking at DSI and caregiver well-being, one of the many areas in need of further research (Wittich, Jarry, Groulx, Southall, & Gagné, 2016).

This work has several limitations. The RAI-HC is based on subjective evaluations of vision, hearing and cognition. The assessment can draw on behavioral test results if they are included in the medical chart. The RAI-HC also captures information about functioning in these domains; however, it cannot quantify these impairments objectively. The assessment does not capture the use of assistive devices (e.g., glasses or hearing aids) or the history of rehabilitation services that have been accessed, thereby limiting our ability to understand how sensory rehabilitation and accommodation for sensory disabilities might influence the rate of change in cognition or communication. In addition, we cannot determine the temporal sequence between the onset of cognitive challenges and the onset of sensory impairments. It is possible that some individuals with a new sensory challenge had a change in their cognitive functioning that preceded the changes in sensory functioning. Given that there was a year, on average, between the initial assessment and the identification of the sensory impairment, changes in cognition may have taken place during this time, which could have influenced some of our study outcomes. We attempted to adjust for this in our multivariate models, but there remains the possibility of residual confounding based on other unmeasured factors.

Despite these limitations, a standardized assessment, like the RAI-HC, is vital to create real-time information with which clinicians can develop a person-centred care plan and respond quickly to ongoing changes for the person and their family. Approximately one third of home care clients in Ontario are likely to be identified as having new sensory challenges over time, with an associated deterioration in their communication and cognitive performance. Although our results focus on data from Ontario, multiple other provinces (e.g., Alberta, British Columbia, Nova Scotia, Manitoba) also use the RAI-HC, making our findings relevant to these other regions as well.

Clinicians within this sector are clearly working with a complex group of individuals who have multiple health conditions and unique needs. Hearing impairment is an important risk factor in the development of cognitive challenges (Lin & Albert, 2014). Although screening for hearing and vision impairment is important, it is recognized that effective sensory interventions (e.g., assistive technologies, vision/hearing rehabilitation) and contact with health care professionals are often under-utilized strategies (Davis et al., 2016; Klaver, Wolfs, Vingerling, Hofman, & de Jong, 1998; Lin, Thorpe, Gordon-Salant, & Ferrucci, 2011; Overbury & Wittich, 2011). This may be partly explained by a lack of knowledge surrounding screening among those with cognitive challenges

(McGilton et al., 2016). Consequently, there is an ongoing requirement for better training and education for home care clinicians to be able to effectively screen for these impairments and put in place a plan of care and/or referrals to maximize the person's functional abilities and use of their residual vision and hearing. Earlier identification and care planning to accommodate sensory impairments would enable these clients to maximize their independence and quality of life.

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