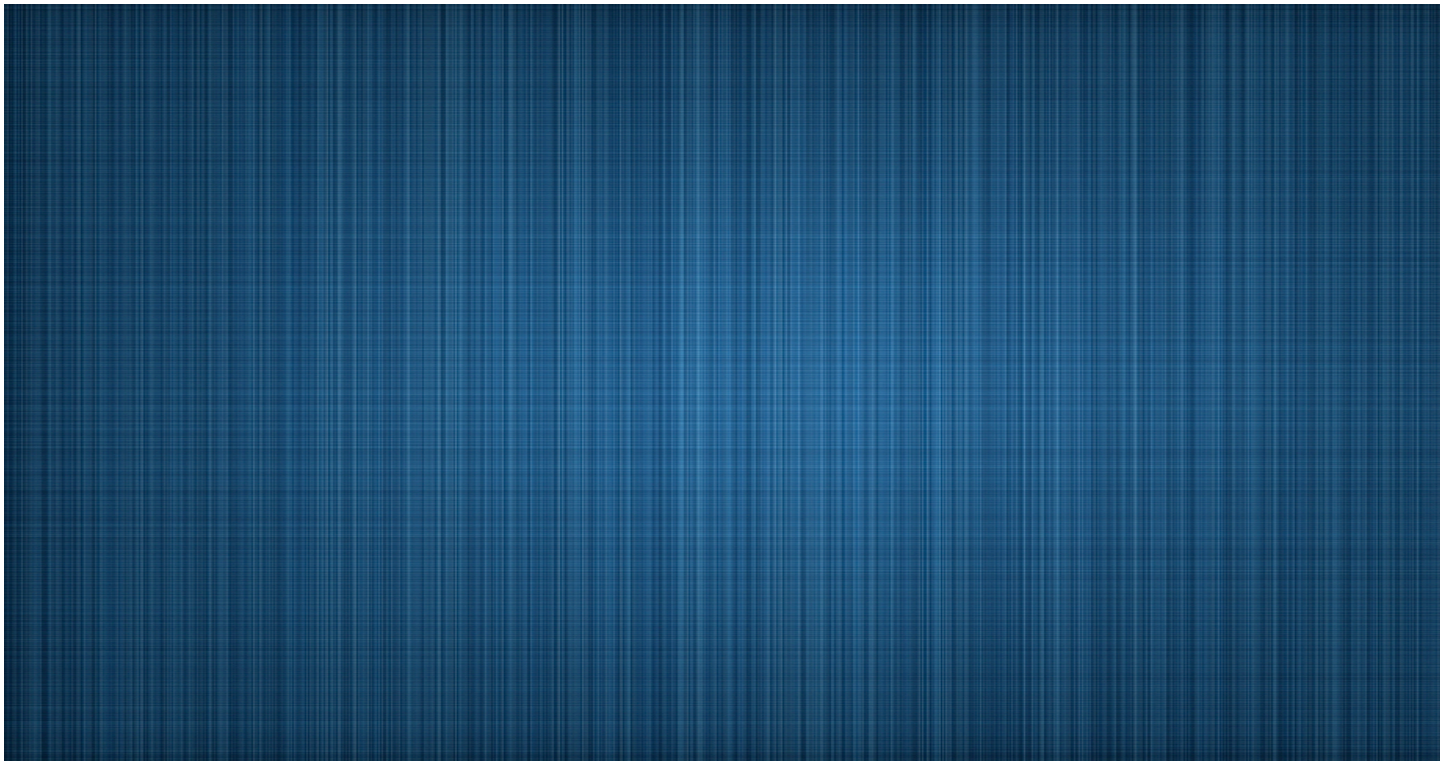

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Rural Dementia Action Research (RaDAR) Team
and Saskatchewan Health Quality Council
Report 2

Simultaneous Time Trends in Dementia Incidence and Prevalence, 2005-2013, Saskatchewan, Canada

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Executive Summary

The last decade has seen several noteworthy original studies of time trends in dementia epidemiology that have reported mixed results. These discrepancies may be partly due to variations in methods, study periods, and populations. One other original study of simultaneous trends in recent dementia incidence and prevalence has been published within the last decade, aside from the present study. The present study used linked administrative health data, for the period 2005/06 to 2012/13, for the province of Saskatchewan to: (1) investigate simultaneous time trends in 12-month age- and sex-specific dementia incidence and prevalence among individuals 45 years and older, and (2) examine the time trends in incidence by database of identification.

We employed a population-based retrospective cohort study design, extracting data from 7 Saskatchewan administrative health databases, linked by a unique anonymized identification number. The cohort consisted of individuals aged 45 and older at their first identification of dementia between April 1, 2005 and March 31, 2013. We drew on 4 of the 7 administrative health databases (hospital discharge abstracts, physician service claims, prescription drug, and RAI-MDS, i.e., long-term care) to develop the case definition algorithm.

Between 2005/06 and 2012/13, the 12-month age-standardized incidence rate of dementia declined significantly ($p < 0.0001$) by 11.07% (from 8.41 to 7.48 per 1,000 population at risk [PAR]) and the absolute number of incident cases dropped by 3.51% (from 3,389 to 3,270). Despite an increase of 11.38% in the PAR, the decline in the incidence rate was observed in every database of identification.

From 2005/06 to 2012/13, the 12-month age-standardized prevalence rate increased significantly ($p < 0.0001$) by 30.54% (from 21.35 to 27.87 per 1,000 PAR) and the absolute number of prevalent cases rose by 47.95% (from 8,795 to 13,012). During the same time period, the PAR increased by 12.16%. Most of the increase took place in the first four years of the study period, slowing between 2009/10 and 2012/13.

We observed a simultaneous trend of decreasing incidence and increasing prevalence of dementia over a relatively short 8-year period in the province of Saskatchewan. A lower incidence rate of dementia may be partly due to several factors, including rising education levels, healthier behaviours, and better treatment of vascular risks. Higher prevalence, and subsequently increased survival time with dementia, may be partly on account of better health services (including earlier diagnosis, possibly) and institutional care. Given the short 8-year study period, these time trends should continue to be observed over time.

Background

Dementia refers to a "clinical syndrome of cognitive decline" that interferes with daily functioning and generally occurs alongside behaviour and personality changes; the decline must not be the result of delirium or another condition (i.e., medical, neurological, or psychiatric) (Chertkow *et al.*, 2013). The most common causes of dementia are Alzheimer's disease (50-75%), vascular dementia (20-30%), frontotemporal dementia (5-10%), and dementia with Lewy bodies (<5%) (Alzheimer's Disease International, 2014).

Incidence of dementia among adults aged 60-64 years is an estimated 3.1 per 1,000 person years and doubles every 5.9 years (World Health Organization, 2012). Females are no more likely than males to develop dementia, given the small sex differences in incidence across all age groups (Thies and Bleiler, 2013). However, prevalence is an estimated 19-29% lower among males than females aged 60 and older, with the exception of Asia Pacific and North America where prevalence is higher among men than women younger than aged 80 (World Health Organization, 2012). Depending upon world region, dementia prevalence ranges from 5-7% among all individuals aged 60 and older (World Health Organization, 2012). Prevalence among those aged 60-64 ranges from 0.3-1.8% and doubles with every 5.5-6.7 years of age (World Health Organization, 2012). Early onset dementia (i.e., before age of 65) accounts for approximately 6-9% of all prevalence (Prince *et al.*, 2013).

Original studies published over the last decade reporting time trends in dementia have reported mixed results. Some key studies provide evidence of declining incidence (Rocca *et al.*, 2011; Schrijvers *et al.*, 2012; Qiu *et al.*, 2013) and others indicate declining prevalence (Lobo *et al.*, 2007; Langa *et al.*, 2008; Matthews *et al.*, 2013). In contrast, other research reveals increasing or stable dementia prevalence (Hall *et al.*, 2009; Sekita *et al.*, 2010; Mathillas *et al.*, 2011; Bertrand *et al.*, 2013; Jacklin *et al.*, 2013; Qiu *et al.*, 2013). To the best of our knowledge, only one other original study that examined simultaneous trends in recent dementia incidence and prevalence has been published within the last 10 years (Qiu *et al.*, 2013). See **Box 1** for a brief overview of selected original studies of time trends in dementia that have been published in the last decade.

Box 1. Summary of selected original studies of time trends in dementia

Incidence

Qiu et al. (2013) found that age-standardized dementia prevalence remained stable in a prospective cohort study of two 6-year cohorts aged 75 and older from 1987-89 and 2001-04 in central Stockholm, Sweden. Dementia incidence was not assessed directly, however, survival time based on 6-year follow-up was significantly longer for the later than earlier cohort, leading Qiu and colleagues to suggest that incidence decreased over the study period. In Rotterdam, the Netherlands, **Schrijvers et al. (2012)** conducted a prospective cohort study to compare incidence between two five-year cohorts aged 60-90. The age-adjusted incidence rate, based on DSM-III-R diagnostic criteria for both cohorts, declined across every age group and by 25% overall (female 28%; male 23%) from the 1990 to the 2000 cohort (overall from 6.56 to 4.92; females from 6.78 to 5.20; males from 6.25 to 4.48 per 1,000 person-years). The overall decline approached statistical significance, and Schrijvers et al. suggested that the findings underestimated the reduction in incidence rates due to a lower mortality rate in the 2000 compared to 1990 cohort. **Rocca et al. (2011)** reported that annual dementia incidence rates based on linked medical records between 1975 and 1994 for individuals aged 70-94 in Rochester (US), fluctuated but ultimately decreased significantly by 30% over the last 10 years of the 20-year study period (1985-94). Rate reductions were particularly apparent among the 80-94 age group; sex-specific findings were not reported.

Prevalence

Using cross-sectional surveys with a two-stage design, **Sekita et al. (2010)** identified four separate cohorts (1985, 1992, 1998, and 2005) aged 65 and older in Hisayama (Japan). Sekita found that the overall age- and sex-adjusted dementia prevalence increased significantly by 38% between 1985 and 2005 (from 6.0 to 8.3 per 100), specifically significant for females at 41% (from 6.6 to 9.3 per 100) but not significant for males at 34% (from 5.4 to 7.2 per 100). Age-specific findings were not reported. In the county of Vasterbotten (Sweden), **Mathillas et al. (2011)** conducted one-phase cross-sectional surveys (field studies) with cohorts aged 85 and older in one city and five rural municipalities in 2000-02 and 2005-07. Based on DSM-IV diagnostic criteria, dementia prevalence over the 5-year period increased significantly by 40% overall (from 26.5 to 37.2 per 100), including a significant increase for females at 33% (from 30.9 to 41.1 per 100) but not significant for males at 44% (from 19.5 to 28.1 per 100). In a retrospective cohort study (registry study) of Alberta (Canada) physician claims data, **Jacklin et al. (2013)** used ICD-9 codes to compare trends in annual dementia prevalence among First Nations and non-First Nations of all ages between 1998 and 2009. Age-adjusted treated dementia prevalence increased at a significantly faster rate among First Nations than non-First Nations, rising 108% among First Nations (from 3.6 to 7.5 per 1,000) compared to 30% among non-First Nations (from 4.3 to 5.6 per 1,000). The annual prevalence rates were higher among non-First Nations females than males over time, but the reverse was observed among non-First Nations sexes. In a retrospective cohort study (registry study) of France's national health care insurance data, **Bertrand et al. (2013)** used antidementia drug prescriptions and ICD-10 codes to determine annual dementia prevalence among individuals aged 65 and older between 2004 and 2010. Data included drug prescriptions, GP or specialist visits, hospitalizations, and other reimbursed health care expenditures. Bertrand et al. found that age- and sex-standardized prevalence increased significantly by 14% overall (from 3.7 to 4.2 per per 100) over the 8-year period. Detailed sex-specific prevalence for the cohorts was not provided.

Box 1, continued

Using cross-sectional surveys with a two-stage design (field study), **Hall et al. (2009)** compared dementia prevalence rates based on DSM-III-R and ICD-10 diagnostic criteria in 1992 and 2001 cohorts of African American aged 70 and older in Indianapolis (US). Hall et al. reported a stable trend in the overall age-standardized prevalence rate (from 6.75 to 7.45 per 100), and prevalence rates higher in the two age groups 80 and older than 79 and under, but not significantly so. Sex-specific findings were not reported. In two-phase cross-sectional surveys conducted in 1988-89 and 1994-96 in Zaragoza (Spain), **Lobo et al. (2007)** determined dementia prevalence on the basis of DSM-IV diagnostic criteria in two cohorts aged 65 and older. The decline in the age- and sex-adjusted prevalence rate of 33% overall (from 5.2 to 3.9 per 100) was not significant; the rate was stable among females (from 4.9 to 5.0 per 100). However, the age-adjusted prevalence rate declined significantly by 60% among males (from 5.8 to 2.3 per 100) particularly among those aged 70-84. **Langa et al.** [2008] determined annual prevalence of cognitive impairment consistent with dementia using secondary analysis of data collected every two years during a national longitudinal study (US). Langa et al. reported that dementia prevalence among those aged 70 and older decreased significantly by 29% overall (from 12.2 to 8.7 per 100). Sex-specific prevalence rates were not reported. In cross-sectional surveys of individuals aged 65 and older in six geographical sections in England and Wales conducted in 1989-94 (two-stage) and 2008-11 (one-stage), **Matthews et al. (2013)** determined prevalence rates of dementia based on DSM-III-R criteria. Age-and sex-standardized prevalence decreased significantly by 24% overall (from 8.3 to 6.5 per 100) over the 20-year study period, including a decrease of 18% among females (from 9.4 to 7.7 per 100) and a decrease of 34% among males (from 7.4 to 4.9 per 100). Sex-specific significance testing was not reported. **Qiu et al. (2013)** found that age-standardized prevalence of dementia, diagnosed based on DSM-III-R criteria at both time periods, remained stable (overall from 17.5 to 17.9; females from 19.2 to 20.5; males from 12.8 to 10.8 per 100).

The value of using retrospective data to examine temporal trends in dementia incidence and prevalence can be illustrated in three key ways. The first of these is the investigation of possible impacts of population-level trends in modifiable risk factors throughout the lifecourse (early, midlife, and late life), on the incidence and prevalence of dementia (Alzheimer's Disease International, 2014). Currently, moderate to robust evidence exists for four domains of modifiable dementia risk factors: developmental (e.g., occupational status, education), psychological (e.g., depression, anxiety, sleep disorders), lifestyle or behaviour (e.g., cigarette use), and cardiovascular (e.g., obesity, cholesterol, hypertension, diabetes) (Alzheimer's Disease International, 2014). Downward trends in dementia incidence over time in populations with documented improvements in these risk factors (e.g., improved education levels and reduced hypertension) would provide further evidence of the association between dementia and these risk factors. The second use of retrospective data in secular trend studies is to provide evidence for the association between trends in dementia and other population-level trends and interventions, including demographics (e.g., aging; Langa *et al.*, 2008; Sekita *et al.*, 2010); life

expectancy (Schrijvers *et al.,* 2012; Qiu *et al.,* 2013); treatment of chronic diseases (e.g., use of statins; Langa *et al.,* 2008; Hall *et al.,* 2009 and hypertensive medications; Langa *et al.,* 2008); treatment of cardiovascular diseases (Mathillas *et al.,* 2011; Schrijvers *et al.,* 2012); health and social care for individuals with dementia (Sekita *et al.,* 2010; Mathillas *et al.,* 2011); and standard of living (Langa *et al.,* 2008). Third, current dementia projection methods are typically based on the assumption that certain factors will remain stable over time, such as age-specific dementia incidence and prevalence (Alzheimer's Disease International, 2013), mortality, and dementia risk factors (except demographics) (Rocca *et al.,* 2011). Such projections do not adequately account for 'changing patterns in risk factors' (Norton *et al.,* 2013), i.e., trends in population-level factors, that can be accounted for in studies based on retrospective data.

There have been several recent original Canadian studies concerning dementia prevalence (Chartier *et al.,* 2012; Fransoo *et al.,* 2009; Gill *et al.,* 2011; Jacklin *et al.,* 2013; Jacklin and Walker 2012; Martens *et al.,* 2010), but only one recent study of trends in prevalence (Jacklin *et al.,* 2013). Further, there have been two original Canadian studies of dementia incidence (CSHA 2000; Tyas *et al.,* 2006), both of which were based on data collected in the mid-1990s, but no recent studies of trends in prevalence.

Using linked administrative health data for the province of Saskatchewan for the time period between 2005/06 and 2012/13, the purposes of this study were to: (1) examine simultaneous age- and sex-specific temporal trends in dementia incidence and prevalence among individuals aged 45 and older, and (2) stratify any changes in incidence by database of identification.

Box 2. Methods

Setting

The province of Saskatchewan is the middle of three Canadian prairie provinces and covers 651,000 km^2 (Saskatchewan Bureau of Statistics, 2014). Between 2006 and 2013, the province's population grew 116,021 (11.7%) from 992,302 to 1,108,303 (Statistics Canada, 2014a). The proportion of the population aged 45-64 grew from 25.1% to 26.1% while the proportion aged 65 and older declined from 15% to 14.4% (Saskatchewan Bureau of Statistics, 2014). Among the 13 provinces and territories, Saskatchewan's growth was third largest, and larger than the national average (Statistics Canada, 2012). The province's population growth of 74,047 between 2006 and 2011 (Saskatchewan Bureau of Statistics, 2014) was largely attributable to interprovincial migration (12,000; 16.2%) and immigration (28,000; 37.8%), with three times more immigrants during this period compared to 2001-2006 (9,800) (Statistics Canada, 2012).

All Saskatchewan residents receive health insurance and constitute the 'covered population' for the present study, with the exception of federally insured residents (e.g., federal prison inmates, members of the Canadian Forces and Royal Canadian Mounted Police) (Saskatchewan Ministry of Health, 2014). The Registered Indian population, and other residents whose costs are covered by another government body, are not included in the province's Prescription Drug Plan (Saskatchewan Ministry of Health, 2010) and therefore are not included in the Prescription Drug Database employed in the current study. Approximately 13% of the Saskatchewan population in 2012 were classified as Registered Indians (Aboriginal Affairs and Northern Development Canada, 2012).

Data sources

Data were extracted from 7 provincial administrative health databases linked by a unique anonymized personal health services number (Saskatchewan Ministry of Health, 2010). Databases describing the demographic characteristics and insurance coverage for the population of Saskatchewan included the *Person Health Registration System*, *Saskatchewan Resident Geography Database*, and the *Vital Statistics* database. The databases from which the cohort were identified were the *Hospital Discharge Abstract Database, Physician Services Claims Database, Prescription Drug Database*, and the *Resident Assessment Instrument – Minimum Data Set* (*RAI-MDS*), which we will refer to as the Long-term Care (i.e., LTC) Database hereafter.

From 2002 onwards, the *Hospital Discharge Abstract Database* includes 5-digit ICD-10-CA codes to record up to 25 diagnoses per record. The *Physician Services Claims Database* includes information used by physicians to claim payment from the provincial government for services provided to patients and a 3-digit ICD-9 diagnosis code associated with the service (maximum of one diagnosis code per service claim) (Saskatchewan Ministry of Health, 2010). The two Prescription Drug Databases include information about the drug dispensed such as classification of drug and drug identification number (DIN), with only Saskatchewan Formulary drugs eligible for coverage. The Long-term Care Database contains assessment information collected at admission to a residential care facility, at regular three-month intervals, and upon significant changes in clinical status (Morris *et al.*, 2010). Admission and quarterly assessment data were included in the present study.

Cohort case definition algorithm

Individuals aged 45 years or older at their first-ever recorded identification of dementia between April 1, 2005 and March 31, 2013 constituted the cohort. 'Early onset dementia' (i.e., before age of 65) affects approximately 6-9% of all prevalent cases (Prince *et al.*, 2013), thus we employed an age cut-off of 45.

Individuals were identified as a dementia case if they met least one of the following criteria: $\geq$1 physician visit (ICD-9 codes 290, 294, 331, 797); $\geq$1 hospitalization (ICD-10-CA codes F00, F01, F02, F03, F04, F05.1, F06.8, F06.9, F09, F10.6, F10.7, F18.6, F18.7, F19.6, F19.7, G30, G31.0, G31.1, G91, R54); $\geq$1 prescription for a cholinesterase inhibitor (Aricept DINs 02232043, 02232044; Exelon DINs: 02242115-02242118, 02245240; Reminyl DINs: 02244298-02244300, 02266717, 02266725, 02266733); or – in the LTC database – a Cognitive Performance Scale score of 2 and over and/or a disease category of Alzheimer's disease or dementia other than Alzheimer's disease. Equivalent to an

Box 2, continued

average Mini Mental State Examination score of 19 or lower (Bartfay *et al.,* 2013), a CPS score of 2 or higher indicates dementia at the moderate to severe stage (Perneczky *et al.,* 2006) and possible mild to very severe impairment (Morris *et al.,* 1994). A "washout" period of 5 years prior to the first identification of dementia was used to ensure that we correctly identified incident dementia.

Cohort members were required to have uninterrupted health insurance coverage, operationalized as having a gap in their insurance coverage of no more than 3 days at any time, from five years prior to the date of first identification of dementia (i.e., the "washout period") until they died or moved out of the province. Further details regarding the cohort case definition used in the current study are available elsewhere (Kosteniuk *et al.,* 2015).

Physician and hospital data are commonly used in administrative health data studies of dementia epidemiology, requiring at minimum one physician visit or hospitalization to identify a dementia case (Chartier *et al.,* 2012; Fransoo *et al.,* 2009; Gill *et al.,* 2011; Jacklin *et al.,* 2013; Jacklin *et al.,* 2012; Manitoba Centre for Health Policy, 2012; Martens *et al.,* 2010;). Alzheimer's disease does not have a diagnostic test for confirmation purposes (St Germaine-Smith *et al.,* 2012) and underdiagnosis of dementia is a significant problem (Boustani *et al.,* 2003; Alzheimer's Disease International, 2011; Connolly *et al.,* 2011). Therefore, the case definition algorithm for the present study prioritized sensitivity over specificity.

Independent variables

Age, sex, and administrative health database of first identification were the three independent variables included in the analysis. Age was represented by the categories of 45-54, 55-64, 65-74, 75-84, and 85 years and older. The four administrative health datasets included hospital, physician, prescription drug, and long-term care.

Statistical analysis

The age structure of the total cohort was used to adjust the sex-specific incidence and prevalence rates for age, and 95% confidence intervals (CI) were calculated for all crude and age-standardized rates.

Incident cases were identified for each 12-month period between April 1, 2005 and March 31, 2013. Incident cases met the case definition criteria and had not been previously identified during the washout period between April 1, 2000 and March 31, 2005. The numerator for each 12-month incidence rate was the number of people alive on April 1 of each year, who also met the case definition of dementia between April 1 of that year and March 31 of the following year. The denominator was the population at risk of developing incident dementia (i.e., after removing individuals with prevalent dementia for the same period, the remaining were aged 45 years or older on April 1 of each year with at least one day of health insurance coverage for the 12-month period).

Prevalent cases met the case definition criteria for each 12-month period from April 1 to March 31 for the years 2005 to 2013. The numerator for each 12-month prevalence rate was the number of people alive on April 1 of each year who met the case definition criteria at any time prior to April 1 of that year. Those individuals at risk for prevalent dementia (i.e., all individuals in the covered population aged 45 years or older on April 1 of each year with at least one day of health insurance coverage for the 12-month period) constituted the denominator.

For incidence and prevalence, we calculated the percentage changes between 2005/06 and 2012/13 in absolute number (*n*), percentage, population at risk (PAR), and age-standardized rate per 1,000 PAR, by dividing the difference between the two figures by the earlier figure and multiplying by 100. Percentage changes in age-standardized incidence and prevalence rates per 1,000 PAR were compared for significant differences ($p < 0.05$) using the x^2 test, and 95% confidence intervals (CI) were calculated for all crude and age-standardized rates. All analyses were completed with SAS 9.3 (SAS Institute Inc, Cary NC).

Results

Incidence

As shown in Figure 1, the overall age-standardized incidence rate of dementia among individuals 45 years and older declined gradually and steadily from 2005/06 until 2010/11, rising slightly in 2011/12 before dropping again in 2012/13. Table 1 indicates that the annual population at risk for incidence rose steadily each year between 2005/06 to 2012/13. As shown in Table 2, the population at risk increased by 11.38% from 403,123 to 449,012 while the absolute number of overall incident cases dropped by 3.51% from 3,389 to 3,270 between 2005/06 and 2012/13. The overall age-standardized incidence rate declined significantly by 11.07% ($p < 0.0001$) from 8.41 to 7.48 per 1,000 PAR over the 8-year period.

Table 2 shows that although the female and male populations at risk increased between 2005/06 and 2012/13 (10.12% and 12.73% respectively), the absolute number of incident cases among females dropped while the absolute number of incident cases among males rose. Consequently, the age-standardized incidence rate decreased more markedly among females than males, dropping significantly by 12.97% ($p < 0.0001$) among females (from 8.31 to 7.23 per 1,000 PAR) compared to 8.39% ($p = 0.0072$) among males (from 8.56 to 7.84 per 1,000 PAR). The proportion of incident cases attributed to females vs. males dropped as well, by 3.66% from 59.89% to 57.71%. The age-standardized incidence rate was slightly higher among males than females in 2005/06 (8.56 vs. 8.31 per 1,000 PAR) and remained so in 2012/13 (7.84 vs. 7.23 per 1,000 PAR).

Overall mean age at identification in 2005/06 (81.67 $\pm$ 9.98 years) did not change significantly ($p = 0.24$) in 2012/13 (81.97 $\pm$ 10.70 years). As shown in Table 2, the population at risk changed most substantially in the 55-64 and 65-74 age groups, increasing 16-31% among females and 20-32% among males. Despite this, the age-standardized incidence rate in the 55-64 age group did not change significantly over time for either sex. Among females, significant declines in age-standardized incidence rates were apparent in the three oldest age groups, ranging from 11.97% ($p = 0.0377$) in those aged 85 and older (from 74.53 to 65.61 per 1,000 PAR) to 15.40% ($p = 0.0396$) in those aged 65-74 (from 4.85 to 4.10 per 1,000 PAR). A significant decline of 18.97% ($p = 0.0136$) in the age-standardized incidence rate among males was apparent only among those aged 65-74 (from 5.25 to 4.25 per 1,000 PAR). The population at risk remained stable and neither sex in the 45-54 age group experienced significant changes in age-standardized incidence rates over time.

In terms of the databases where incident cases of dementia were first identified, the greatest proportion were first identified in long-term care in 2005/06 (35.35%) and 2012/13 (34.98%) (Table 2). The declines over time in the crude incidence rates per 1,000 PAR over time were significant across every database with the exception of Prescription Drug, with similar declines in the Physician (14.17%; $p = 0.0007$), Long-term Care (14.14%; $p = 0.0002$) and Hospital databases (12.97%; $p = 0.0022$).

Prevalence

Figure 2 shows that the overall age-standardized prevalence rate among those aged 45 and older increased between 2005/06 to 2012/13. Most of the increase took place in the first four years of the study period, with the upward trend slowing between 2009/10 and 2012/13. Over the 8-year period, the absolute number of overall prevalent cases rose 47.95% from 8,795 to 13,012, compared to an increase of 12.16% in the population at risk for prevalence from 411,918 to 462,024 (Table 1 and Table 3). The overall age-standardized prevalence rate increased significantly ($p < 0.0001$) by 30.54% over time from 21.35 to 27.87 per 1,000 PAR.

As shown in Table 3, the population at risk increased slightly more among males than females (13.36% vs. 11.05%), as did the absolute number of prevalent cases (51.22% vs. 46.03%). As a result, the age-standardized prevalence rate increased significantly ($p < 0.0001$) in both sexes, but to a slightly greater degree by 32.38% among males (from 20.51 to 27.15 per 1,000 PAR) compared to 29.48% among females (from 21.88 to 28.33 per 1,000 PAR). The proportion of prevalent cases attributed to males relative to females rose as well, from 36.94% to 37.76% (2.33%). However, the age-standardized incidence rate was slightly higher among females than males in 2005/06 (21.88 vs. 20.51 per 1,000 PAR) and remained so in 2012/13 (28.33 vs. 27.15 per 1,000 PAR).

Similar to increases in the population at risk for incident cases, the largest increases in the PAR for prevalent cases took place in the 55-64 and 65-74 age groups. With the exception of the 45-54 age group, significant increases in age-standardized prevalence rates were apparent in every age group for both sexes. The largest increase in the age-standardized prevalence rate for both sexes took place in the 55-64 age group (107.08% female, $p < 0.0001$; 48.72% male, $p < 0.0001$) and the smallest increase was experienced by the 85 and older age group (23.98% female, $p < 0.0001$; 23.86% male; $p < 0.0001$).

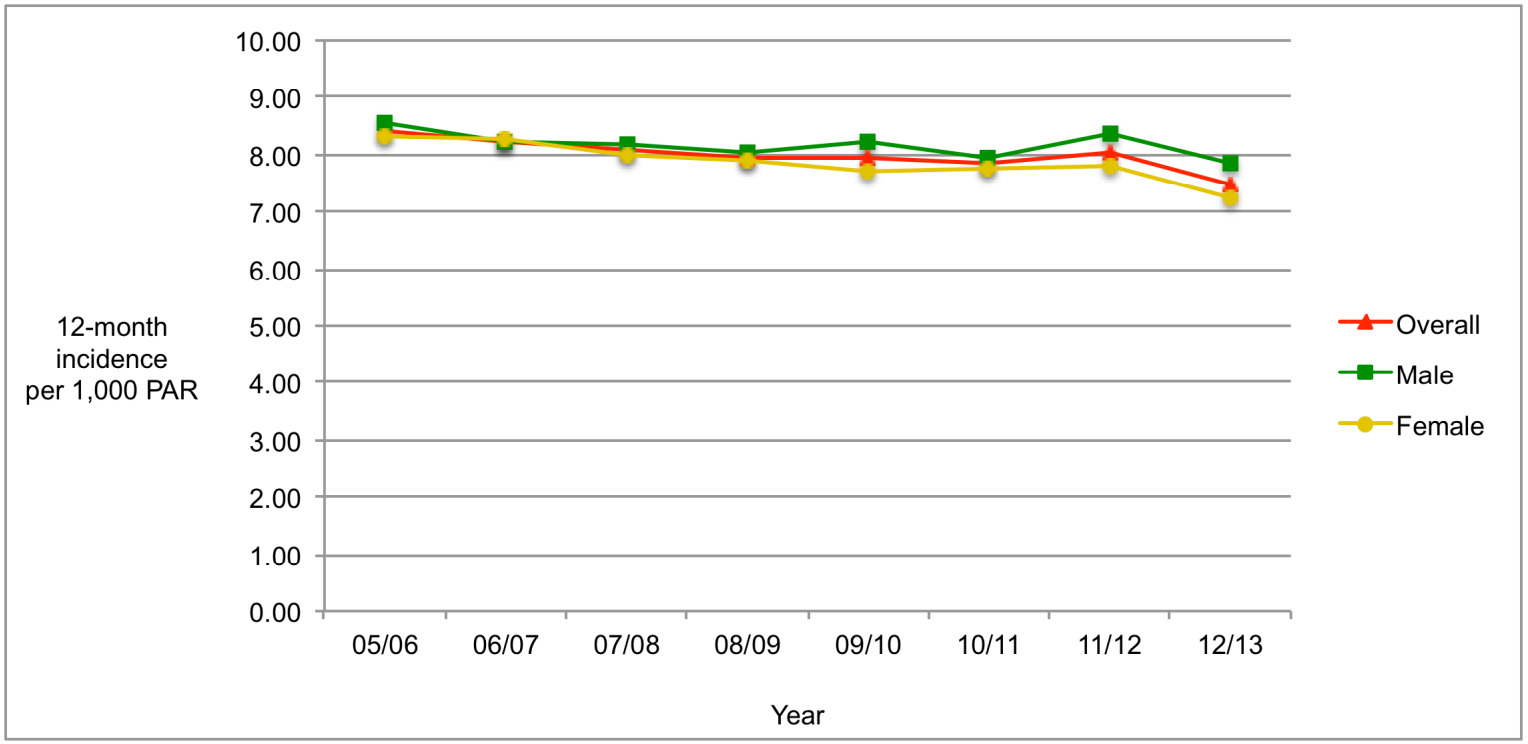

Figure 1 Age-standardized 12-month incidence of dementia among adults 45 years of age and older, Saskatchewan, from 2005/06 to 2012/13

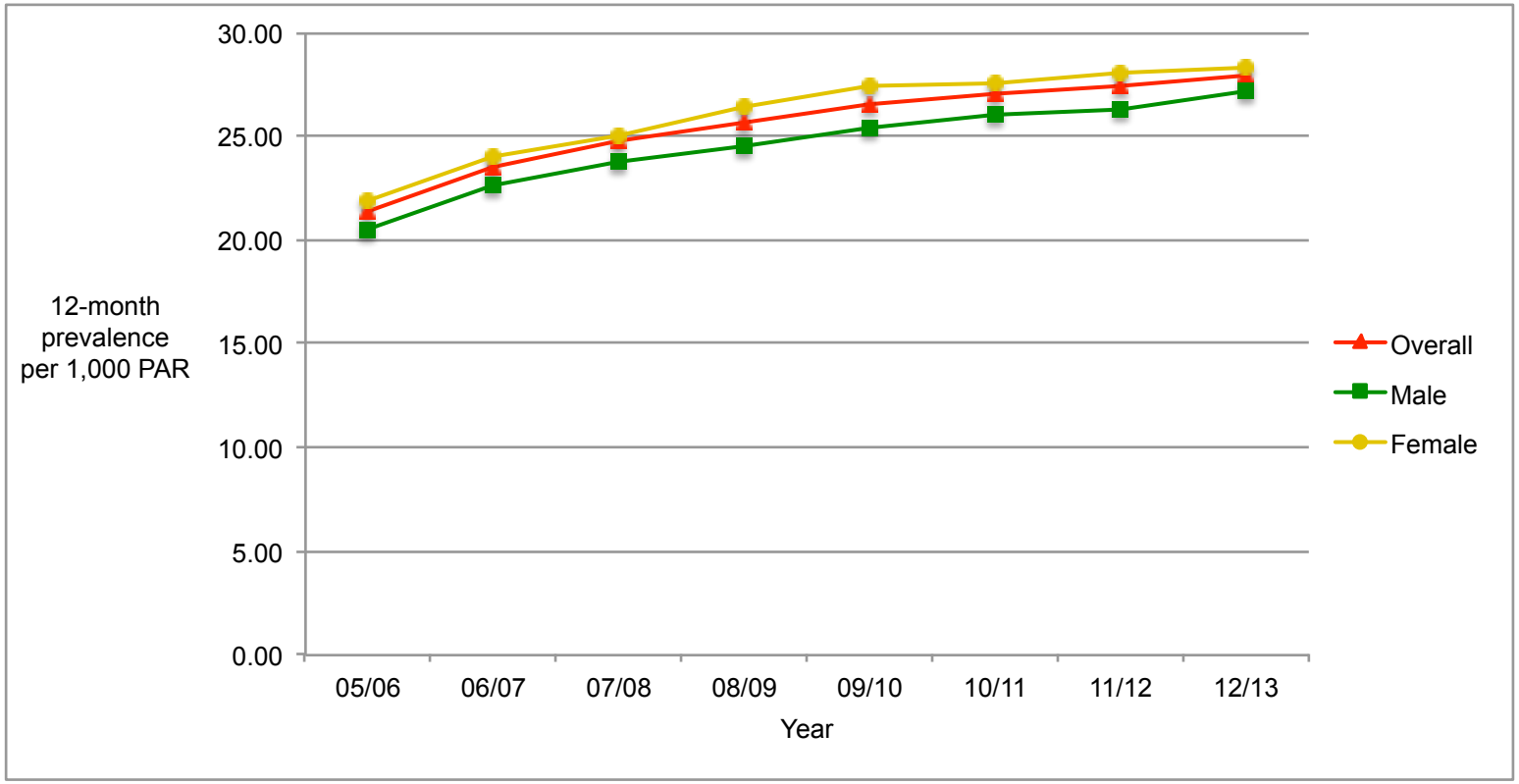

Figure 2 Age-standardized 12-month prevalence of dementia among adults 45 years of age and older, Saskatchewan, from 2005/06 to 2012/13

Table 1 12-month incidence and prevalence of dementia among adults 45 years of age and older, Saskatchewan, from 2005/06 to 2012/13

	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Incidence								
Total population at risk (PAR)	403,123	407,409	417,605	426,839	431,628	438,941	445,187	449,012
Incident cases	3,389	3,338	3,314	3,312	3,320	3,346	3,475	3,270
Crude incidence								
Female	9.77 (9.35-10.20)	9.66 (9.24-10.08)	9.25 (8.85-9.67)	9.05 (8.66-9.46)	8.80 (8.41-9.20)	8.88 (8.49-9.27)	8.89 (8.51-9.28)	8.25 (7.88-8.63)
Male	6.96 (6.59-7.34)	6.64 (6.28-7.00)	6.54 (6.19-6.90)	6.40 (6.06-6.75)	6.53 (6.19-6.88)	6.31 (5.98-6.65)	6.68 (6.34-7.03)	6.28 (5.95-6.62)
Overall	8.41 (8.13-8.69)	8.19 (7.92-8.47)	7.94 (7.67-8.21)	7.76 (7.50-8.03)	7.69 (7.43-7.96)	7.62 (7.37-7.88)	7.81 (7.55-8.07)	7.04 (7.04-7.54)
Rate of age-standardized incidence (to 2005/06 total Sask. population)								
Female	8.31 (7.95-8.68)	8.26 (7.91-8.63)	8.00 (7.65-8.36)	7.90 (7.56-8.26)	7.72 (7.38-8.07)	7.75 (7.42-8.10)	7.79 (7.46-8.14)	7.23 (6.91-7.56)
Male	8.56 (8.11-9.02)	8.20 (7.76-8.66)	8.19 (7.75-8.64)	8.05 (7.63-8.50)	8.23 (7.80-8.67)	7.95 (7.53-8.39)	8.38 (7.96-8.82)	7.84 (7.43-8.26)
Overall	8.41 (8.13-8.69)	8.24 (7.96-8.52)	8.07 (7.80-8.35)	7.96 (7.69-8.24)	7.92 (7.65-8.19)	7.83 (7.57-8.10)	8.03 (7.76-8.30)	7.48 (7.22-7.74)
Prevalence								
Total population at risk (PAR)	411,918	417,297	428,269	438,069	443,466	451,222	457,822	462,024
Prevalent cases	8,795	9,888	10,664	11,230	11,838	12,281	12,635	13,012
Crude prevalence								
Female	26.00 (25.33-26.68)	28.84 (28.14-29.55)	30.47 (29.76-31.19)	31.46 (30.74-32.19)	32.87 (32.14-33.61)	33.32 (32.60-34.06)	33.79 (33.06-34.53)	34.19 (33.46-34.93)
Male	16.36 (15.81-16.93)	18.16 (17.58-18.76)	18.94 (18.36-19.54)	19.42 (18.84-20.02)	20.12 (19.53-20.72)	20.74 (20.15-21.35)	21.06 (20.47-21.67)	21.82 (21.22-22.43)
Overall	21.35 (20.91-21.80)	23.70 (23.24-24.16)	24.90 (24.44-25.37)	25.64 (25.17-26.11)	26.69 (26.22-27.17)	27.22 (26.74-27.70)	27.60 (27.13-28.08)	28.16 (27.69-28.64)
Rate of age-standardized prevalence (to 2005/06 total Sask. population)								
Female	21.88 (21.31-22.45)	24.04 (23.45-24.63)	25.04 (24.85-26.05)	26.35 (25.75-26.96)	27.37 (26.77-27.99)	27.59 (26.99-28.20)	28.04 (27.44-28.65)	28.33 (27.73-28.94)
Male	20.51 (19.81-21.22)	22.65 (21.92-23.39)	23.81 (23.07-24.86)	24.53 (23.80-25.29)	25.35 (24.60-26.10)	26.06 (25.31-26.82)	26.31 (25.57-27.07)	27.15 (26.40-27.91)
Overall	21.35 (20.91-21.80)	23.50 (23.05-23.97)	24.82 (24.35-25.29)	25.65 (25.19-26.13)	26.60 (26.13-27.07)	27.00 (26.53-27.48)	27.37 (26.90-27.85)	27.87 (27.40-28.35)

Table 2 Change in 12-month incidence of dementia among adults 45 years of age and older, Saskatchewan, 2005/06 to 2012/13

	2005/06 n = 3,389					2012/13 n = 3,270					Change from 2005/06 to 2012/13 (%)				
	n	%	PAR	Crude rate per 1,000 PAR	Age-standardized rate per 1,000 PAR	n	%	PAR	Crude rate per 1,000 PAR	Age-standardized rate per 1,000 PAR	n	%	PAR	Age-stand. rate per 1,000 PAR	p-value[a]
Female	2,030	59.89	207,766	9.77 (9.35-10.20)	8.31 (7.95-8.68)	1,887	57.71	228,782	8.25 (7.88-8.63)	7.23 (6.91-7.56)	-7.04	-3.64	10.12	-12.97	<0.0001
Male	1,359	40.10	195,357	6.96 (6.59-7.34)	8.56 (8.11-9.02)	1,383	42.29	220,230	6.28 (5.95-6.62)	7.84 (7.43-8.26)	1.77	5.46	12.73	-8.39	0.0072
Database															
Physician	1,023	30.19	403,123	2.54	n/a	979	29.94	449,012	2.18	n/a	-4.30	-0.83	11.38	-14.17[b]	0.0007
Hospital	964	28.44	403,123	2.39	n/a	933	28.53	449,012	2.08	n/a	-3.22	0.32	11.38	-12.97[b]	0.0022
Prescription Drug	204	6.02	403,123	0.51	n/a	214	6.54	449,012	0.48	n/a	4.90	8.64	11.38	-5.88[b]	0.5376
LTC	1,198	35.35	403,123	2.97	n/a	1,144	34.98	449,012	2.55	n/a	-4.51	-1.05	11.38	-14.14[b]	0.0002
Female															
45-54	35	1.72	75,340	0.46 (0.32-0.65)	0.47 (0.32-0.65)	37	1.96	75,597	0.49 (0.34-0.67)	0.46 (0.32-0.63)	5.71	13.95	0.34	-1.46	0.8249
55-64	60	2.96	51,927	1.16 (0.88-1.49)	1.15 (0.88-1.48)	85	4.50	67,958	1.25 (1.00-1.55)	1.23 (0.99-1.53)	41.67	52.03	30.87	7.16	0.6390
65-74	178	8.77	36,476	4.88 (4.19-5.65)	4.85 (4.17-5.62)	165	8.74	42,193	3.91 (3.34-4.55)	4.10 (3.50-4.78)	-7.30	-0.34	15.67	-15.40	0.0396
75-84	656	32.32	29,487	22.25 (20.59-24.00)	21.91 (20.28-23.63)	539	28.56	27,767	19.41 (17.82-21.10)	19.03 (17.47-20.69)	-17.84	-11.63	-5.83	-13.15	0.0177
85+	1,101	54.24	14,536	75.74 (71.49-80.16)	74.53 (70.35-78.88)	1,061	56.22	15,267	69.50 (65.51-73.65)	65.61 (61.85-69.53)	-3.63	3.65	5.03	-11.97	0.0377
All ages	2,030	100.00	207,766	9.77 (9.35-10.20)	8.31 (7.95-8.68)	1,887	100.00	228,782	8.25 (7.88-8.63)	7.23 (6.91-7.56)	-7.04	0	10.12	-12.97	<0.0001
Male															
45-54	42	3.09	77,416	0.54 (0.39-0.73)	0.54 (0.39-0.73)	33	2.39	77,592	0.43 (0.29-0.60)	0.40 (0.27-0.56)	-21.43	-22.65	0.23	-26.24	0.294
55-64	74	5.45	52,879	1.40 (1.10-1.76)	1.40 (1.10-1.76)	92	6.65	69,958	1.32 (1.06-1.61)	1.30 (1.59-1.05)	24.32	22.02	32.30	-7.51	0.6903
65-74	178	13.10	34,121	5.22 (4.48-6.04)	5.25 (4.51-6.08)	164	11.86	41,005	4.00 (3.41-4.66)	4.25 (3.63-4.96)	-7.87	-9.47	20.18	-18.97	0.0136
75-84	499	36.72	23,228	21.48 (19.66-23.43)	21.91 (20.05-23.89)	475	34.35	22,849	20.79 (18.98-22.72)	20.86 (1905-22.80)	-4.81	-6.45	-1.63	-4.77	0.6046
85+	566	41.65	7,713	73.38 (67.66-79.43)	75.70 (69.79-81.93)	619	44.76	8,826	70.13 (64.89-75.66)	71.46 (66.12-77.09)	9.36	7.47	14.43	-5.60	0.4201
All ages	1,359	100	195,357	6.96 (6.59-7.34)	8.56 (8.11-9.02)	1,383	100.00	220,230	6.28 (5.95-6.62)	7.84 (7.43-8.26)	1.77	0	12.73	-8.39	0.0072
Overall															
45-54	77	2.27	152,756	0.50 (0.40-0.63)	0.50 (0.40-0.63)	70	2.14	153,189	0.46 (0.36-0.58)	0.43 (0.33-0.54)	-9.09	-5.73	0.28	-14.96	0.5521
55-64	134	3.95	104,806	1.28 (1.07-1.51)	1.28 (1.07-1.51)	177	5.41	137,916	1.28 (1.10-1.49)	1.27 (1.09-1.47)	32.09	36.96	31.59	-0.91	0.9737
65-74	356	10.50	70,597	5.04 (4.53-5.59)	5.04 (4.53-5.59)	329	10.06	83,198	3.95 (3.54-4.40)	4.18 (3.74-4.65)	-7.58	-4.19	17.85	-17.16	0.0014
75-84	1,155	34.08	52,715	21.91 (20.68-23.20)	21.91 (20.68-23.20)	1,014	31.01	50,616	20.03 (18.83-21.29)	19.85 (18.66-21.09)	-12.21	-9.01	-3.98	-9.42	0.0354
85+	1,667	49.19	22,249	74.92 (71.50-78.46)	74.92 (71.50-78.46)	1,680	51.38	24,093	69.73 (66.55-73.02)	67.65 (64.56-70.84)	0.78	4.45	8.29	-9.70	0.0309
All ages	3,389	100	403,123	8.41 (8.13-8.69)	8.41 (8.13-8.69)	3,270	100	449,012	7.28 (7.04-7.54)	7.48 (7.22-7.74)	-3.51	0	11.38	-11.07	<0.0001

[a] Test of difference between rate of incident dementia in 2005/06 vs 2012/13

[b] Change in crude rate per 1,000 PAR

Table 3 Change in 12-month prevalence of dementia among adults 45 years of age and older, Saskatchewan, 2005/06 to 2012/13

	2005/06 n = 3,389					2012/13 n = 3,270					Change from 2005/06 to 2012/13 (%)				
	n	%	PAR	Crude rate per 1,000 PAR	Age-standardized rate per 1,000 PAR	n	%	PAR	Crude rate per 1,000 PAR	Age-standardized rate per 1,000 PAR	n	%	PAR	Age-stand. rate per 1,000 PAR	p-value[a]
Female	5,546	63.06	213,312	26.00 (25.33-26.68)	21.88 (21.21-22.45)	8,099	62.24	236,881	34.19 (33.46-34.93)	28.33 (27.73-28.94)	46.03	-1.36	11.05	29.48	<0.0001
Male	3,249	36.94	198,606	16.36 (15.81-16.93)	20.51 (19.81-21.22)	4,913	37.76	225,143	21.82 (21.22-22.43)	27.15 (26.40-27.91)	51.22	2.33	13.36	32.38	<0.0001
Female															
45-54	94	1.69	75,434	1.25 (1.01-1.53)	1.25 (01.01-1.53)	110	1.36	75,707	1.45 (1.19-1.75)	1.33 (1.09-1.60)	17.02	-19.53	0.36	6.48	0.2733
55-64	163	2.94	52,090	3.13 (2.67-3.65)	3.12 (2.66-3.64)	446	5.51	68,404	6.52 (5.93-7.15)	6.47 (5.88-7.09)	173.62	87.41	31.32	107.08	<0.0001
65-74	414	7.46	36,890	11.22 (10.17-12.35)	11.17 (10.13-12.29)	694	8.57	42,887	16.18 (15.01-17.42)	16.79 (15.57-18.07)	67.63	14.88	16.26	50.27	<0.0001
75-84	1623	29.26	31,110	52.17 (49.73-54.70)	51.30 (48.90-53.79)	2,034	25.11	29,801	68.25 (65.42-71.18)	66.75 (63.97-69.61)	25.32	-14.18	-4.21	30.11	<0.0001
85+	3252	58.64	17,788	182.82 (177.16-188.58)	179.17 (173.63-184.82)	4,815	59.45	20,082	239.77 (233.88-245.73)	222.14 (216.68-227.66)	48.06	1.38	12.90	23.98	<0.0001
All ages	5,546	100.00	213,312	26.00 (25.33-26.68)	21.88 (21.21-22.45)	8,099	100.00	236,881	34.19 (33.46-34.93)	28.33 (27.73-28.94)	46.03	0.00	11.05	29.48	<0.0001
Male															
45-54	88	2.71	77,504	1.14 (0.91-1.40)	1.13 (0.91-1.39)	101	2.06	77,693	1.30 (1.06-1.58)	1.19 (0.97-1.45)	14.77	-23.99	0.24	5.39	0.3354
55-64	216	6.65	53,095	4.07 (3.55-4.65)	4.08 (3.55-4.66)	430	8.75	70,388	6.11 (5.55-6.71)	6.06 (5.50-6.66)	99.07	31.58	32.57	48.72	<0.0001
65-74	438	13.48	34,559	12.67 (11.52-13.91)	12.74 (11.58-13.98)	697	14.19	41,702	16.71 (15.51-17.99)	17.52 (16.25-18.86)	59.13	5.27	20.67	37.54	<0.0001
75-84	1153	35.49	24,381	47.29 (44.66-50.03)	48.33 (45.65-51.13)	1,653	33.65	24,502	67.46 (64.35-70.68)	67.66 (64.54-70.89)	43.37	-5.18	0.50	39.99	<0.0001
85+	1354	41.67	9,067	149.33 (142.06-156.84)	155.55 (147.97-163.36)	2,032	41.36	10,858	187.14 (179.85-194.61)	192.66 (185.15-200.35)	50.07	-0.74	19.75	23.86	<0.0001
All ages	3,249	100.00	198,606	16.36 (15.81-16.93)	20.51 (19.81-21.22)	4,913	100.00	225,143	21.82 (21.22-22.43)	27.15 (26.40-27.91)	51.22	0.00	13.36	32.38	<0.0001
Overall															
45-54	182	2.07	152,938	1.19 (1.02-1.38)	1.19 (1.02-1.38)	211	1.62	153,400	1.38 (1.20-1.57)	1.26 (1.10-1.44)	15.93	-21.74	0.30	5.97	0.1512
55-64	379	4.31	105,185	3.60 (3.25-3.98)	3.60 (3.25-3.98)	876	6.73	138,792	6.31 (5.90-6.74)	6.26 (5.86-6.69)	131.13	56.15	31.95	73.77	<0.0001
65-74	852	9.69	71,449	11.93 (11.14-12.75)	11.93 (11.14-12.75)	1,391	10.69	84,589	16.44 (15.60-17.32)	17.15 (16.26-18.06)	63.26	10.32	18.39	43.77	<0.0001
75-84	2776	31.56	55,491	50.03 (48.23-51.87)	50.0348.23-51.87)	3,687	28.34	54,303	67.90 (65.80-70.05)	67.16 (65.08-69.28)	32.82	-10.20	-2.14	34.24	<0.0001
85+	4606	52.37	26,855	171.51 (167.02-176.08)	171.51 (167.02 – 176.08)	6,847	52.62	30,940	221.30 (216.68-225.97)	212.49 (208.06-216.97)	48.65	0.48	15.21	23.89	<0.0001
All ages	8,795	100.00	411,918	21.35 (20.91-21.80)	21.35 (20.91-21.80)	13,012	100.00	462,024	28.16 (27.69-28.64)	27.87 (27.40-28.35)	47.95	0.00	12.16	30.54	<0.0001

[a] Test of difference between rate of prevalent dementia in 2005/06 vs 2012/13

Discussion

Using a population-based retrospective cohort design, we identified incident and prevalent cases of dementia between April 1, 2005 and March 31, 2013 in linked administrative health databases (Hospital Discharge Abstracts, Physician Service Claims, Prescription Drug, and RAI- MDS, i.e., Long-term Care), among individuals 45 years and older at first identification of dementia.

Considering the first study objective to investigate simultaneous age- and sex-specific temporal trends in dementia incidence and prevalence, we found the overall age-standardized incidence rate declined significantly by 11.07% and the age-standardized prevalence rate increased significantly by 30.54% over the 8-year study period. Overall, the incidence rate declined from 8.41 to 7.48 per 1,000 PAR despite an 11.38% increase in the overall population at risk. Although both sexes experienced significant declines in the incidence rate over time, females experienced a slightly larger decrease than males (12.97% vs. 8.39%). The age-standardized incidence rate remained higher among males than females in 2012/13 (7.84 vs. 7.23 per 1,000 PAR) as in 2005/06 (8.56 vs. 8.31 per 1,000 PAR). Among females, significant decreases occurred only in the three oldest age groups, with the largest decline in the 65-74 age group. Among males, only the 65-74 age group experienced a significant decline over the 8-year period.

Overall, the age-standardized prevalence rate increased significantly by 30.54% from 21.35 to 27.87 per 1,000 PAR and population at risk increased by 12.16% between 2005/06 and 2012/13. Males experienced a slightly larger increase than females in the age-standardized prevalence rate over time (32.38% vs. 29.48%). The age-standardized prevalence rate was higher among females than males in 2005/06 (21.88 vs. 20.51 per 1,000 PAR) and remained so in 2012/13 (28.33 vs. 27.15 per 1,000 PAR). Significant increases were apparent in every age group for both sexes (except those 45-54), with the largest increment in the 55-64 age group and the smallest increment in the 85 and older age group for both sexes.

Considering the second study objective to stratify the changes in incidence over the 8-year study period by database of identification, significant decreases in the crude incidence rate per 1,000 PAR were apparent in 3 of the 4 databases examined, with declines of 13-14% across Hospital Discharge Abstracts, Physician Service Claims, and RAI- MDS (i.e., Long-term Care).

Incidence

Our finding of declining dementia incidence over time is consistent with all three original key studies published within the last 10 years on the topic of incidence trends (Rocca *et al.,* 2011; Schrijvers *et al.,* 2012; Qiu *et al.,* 2013), two of which were field studies (Schrijvers *et al.,* 2012; Qiu *et al.,* 2013) and one a registry study (Rocca *et al.,* 2011). Two of the three studies included nursing home residents (Rocca *et al.,* 2011; Qiu *et al.,* 2013), and one study did not specify whether nursing home residents were included (Schrijvers *et al.,* 2012). Specifically, incidence rates declined an average of 2.5-3% per year in two of these studies (Rocca *et al.,* 2011; Schrijvers *et al.,* 2012) compared to 1.5% per year in the current study. Similar to the present study, Schrijvers *et al.,* (2012) observed a slightly greater decrease in the incidence rate over time in females than males; in contrast to the present study, the incidence rate was higher among females than males at both time points.

Prevalence

Four of nine original studies are in line with our finding of rising prevalence over time (Sekita *et al.,* 2010; Mathillas *et al.,* 2011; Bertrand *et al.,* 2013; Jacklin *et al.,* 2013), including two field studies (Sekita *et al.,* 2010; Mathillas *et al.,* 2011) and two registry studies (Bertrand *et al.,* 2013; Jacklin *et al.,* 2013). One of these four studies included nursing home residents (Mathillas *et al.,* 2011), one study did not (Hall *et al.,* 2009; Bertrand *et al.,* 2013), and two studies did not specify whether nursing home residents were included (Sekita *et al.,* 2010; Jacklin *et al.,* 2013). At 4.36% per year, the average annual prevalence rate growth in the present study is in the mid-range of other studies, which varied between 1.9-2% (Sekita *et al.,* 2010; Bertrand *et al.,* 2013), 2.7-9.8% (Jacklin *et al.,* 2013), and 8% (Mathillas *et al.,* 2011). In the present study, males experienced a slightly larger increase than females in the prevalence rate over time, whereas Sekita *et al.,* (2010) observed the reverse. However, the prevalence rate remained higher in females than males over time in the present study, in line with findings from two studies of increasing prevalence trends (Sekita *et al.,* 2010; Mathillas *et al.,* 2011). Contrary to results from the present study, five of nine original studies on the topic of prevalence trends reported a downward (Lobo *et al.,* 2007; Langa *et al.,* 2008; Matthews *et al.,* 2013) or stable temporal trend (Hall *et al.,* 2009; Qiu *et al.,* 2013); these were exclusively field studies. Three of these studies included nursing home residents (Lobo *et al.,* 2007; Qiu *et al.,* 2013; Matthews *et al.,* 2013), and two did not (Langa *et al.,* 2008; Hall *et al.,* 2009).

Variations in the direction and magnitude of change over time in incidence and prevalence rates across studies may be due to differences in methodological approaches (e.g., registry vs. field studies), diagnostic and classification criteria, observation periods, and sample or population characteristics (e.g., age cut-offs, demographic trends in populations). It is important to note that in comparison to field studies, registry studies based on administrative health data, such as the present study, tend to underestimate the true number of individuals with dementia because dementia tends to be under-recognized in the health care system (Lambert *et al.,* 2014).

Possible explanations

Recently published reviews and commentaries offer several possible explanations for decreasing rates of dementia incidence and prevalence over time, as well as for increasing rates of prevalence (Larson and Langa 2012; Banerjee 2013; Larson *et al.,* 2013; Whalley and Smyth 2013; Lee 2014; Sachev 2014; Alzheimer's Disease International, 2014; Alzheimer's Disease International, 2015; Wu et al. 2015). Findings from several original studies provide preliminary supporting evidence for these observations.

First, cognitive reserve as an outcome of higher education and occupational complexity has been cited as a protective factor (Langa *et al.,* 2008) and rising education levels and intellectual demands over time have been linked to declining incidence and prevalence of dementia in later cohorts (Langa *et al.,* 2008; Hall *et al.,* 2009; Rocca *et al.,* 2011; Schrijvers *et al.,* 2012; Matthews *et al.,* 2013). Education levels have been rising in Saskatchewan, reflected in an annual 2.8% growth in the proportion of post-secondary graduates aged 25-64 between 2000 and 2012 (Statistics Canada, 2013a).

Recent evidence from a 25-year longitudinal study supports an association between reduced risk of dementia and healthy lifestyle or behaviour (e.g., non smoking, physical activity, healthy diet, and limited alcohol intake) (Elwood *et al.,* 2013). Increased uptake of healthy behaviours over time has been linked to declining dementia trends (Lobo *et al.,* 2007; Hall *et al.,* 2009; Qiu *et al.,* 2013) as have reduced cardiovascular risks such as prevention of heart disease (Matthews *et al.,* 2013), and decreased hypertension (Qiu *et al.,* 2013), cholesterol (Qiu *et al.,* 2013), and stroke (Rocca *et al.,* 2011). However, a trend of increasing dementia prevalence in Japan has also been attributed to rising rates of obesity, hypercholesterolemia, and other metabolic disorders (Sekita *et al.,* 2010). Population data indicate that

while the rate of non-smoking, physical activity, and fruit/vegetable consumption increased in Saskatchewan over the study period, so too did the rates of obesity, diabetes, and high blood pressure (Elliot, 2014; Statistics Canada, 2013b).

Recent studies support an association between temporal trends of dementia decline and improved treatment of vascular risks (Lobo *et al.,* 2007; Qiu *et al.,* 2013) such as the use of antithrombotic and lipid-lowering drugs (Schrijvers *et al.,* 2012), antihypertensive medications (Langa *et al.,* 2008; Hall *et al.,* 2009) and statins (Langa *et al.,* 2008; Hall *et al.,* 2009; Schrijvers *et al.,* 2012). The most recent available population-level data for Saskatchewan indicate declining annual rates of mortality due to major cardiovascular diseases (Statistics Canada, 2014b), heart diseases, and cerebrovascular diseases (2003-2009) (Statistics Canada, 2013b).

Last, increased dementia prevalence reflects lengthier duration of survival with dementia, possibly owing to improved care and treatment, such as better health services and institutional care (Sekita *et al.,* 2010) and increased cholinesterase inhibitors prescriptions (Mathillas *et al.,* 2013). Langa *et al.,* (2008) proposed the 'compression of cognitive morbidity' hypothesis that declining dementia trends demonstrate a delay of dementia to older age, reflecting the positive association over time between quality of life and brain health. Mathillas *et al.,* (2013) suggested that better treatment of cardiovascular risks and reduced mortality due to cardiovascular disease contributed to a growing pool of Swedish older adults aged 85 and older at risk of dementia, thereby reflecting a trend of increasing dementia prevalence in this age cohort.

In terms of the present study, immigration accounted for 37.8% of total population growth in Saskatchewan between 2006 and 2011 (Statistics Canada, 2012). It is plausible that our observation of declining dementia incidence despite population growth was partly due to limited recognition of dementia during encounters between health care professionals and older adult immigrants to Saskatchewan.

Several interrelated factors potentially account for the limited impact of the declining dementia incidence rate on the prevalence rate of dementia in the current study. The primary explanation may be that the 8-year observation period was too brief to demonstrate an impact. Second, rising prevalence despite declining incidence in the present study indicates that survival time with dementia was also increasing, from 2.56 years in 2005/06 (21.53/8.41) to 3.73 years in 2012/13 (27.87/7.48). Increased survival time and prevalence may be due to identification of dementia in earlier stages and improved treatment after identification. Last, the

declining provincial mortality rate and growth of the overall population at risk aged 45 and older minimized the impact of declining incidence upon prevalence during the short 8-year observation period. Beginning in 2009/10, declining incidence may have begun to manifest in a relatively slower increase in the prevalence rate compared to pre-2009/10, perhaps signalling the beginning of a stabilizing trend in dementia prevalence.

Conclusions

Study limitations

Administrative health data is collected for purposes other than disease surveillance, and as such, several limitations are associated with the use of administrative health data to determine incidence and prevalence of dementia. First, underdiagnosis of dementia is a significant issue, with 31-69% of primary care patients with dementia not receiving a formal documented diagnosis (Boustani *et al.*, 2003; Bradford *et al.*, 2009; Van den Dungen *et al.*, 2012). As a result, studies based on administrative health data (i.e., registry-based studies) tend to produce underestimations of prevalence and incidence in comparison to field studies (i.e., two-phase studies with screening followed by a structured clinical evaluation) (Lambert *et al.*, 2014). However, data linkage across sectors is possible in registry-based studies, allowing community- and institution-dwelling populations to be combined for a more complete picture of dementia epidemiology, in contrast to field studies of dementia epidemiology which typically do not combine these populations (e.g., Herrera *et al.*, 2002; Shaji *et al.*, 2005; Rodriguez *et al.*, 2008; World Health Organization, 2012; Thies and Bleiler, 2013). Second, physician services claims permit a maximum of one diagnosis code per claim, therefore diseases due to dementia may not be captured in these claims if other presenting problems take precedence during patient visits. Finally, our study period of 7 years may be too short to discern a consistent and reliable pattern or trend in dementia over time.

Conclusions

Administrative health data is a valuable research tool in tracking trends in dementia incidence and prevalence. The present study demonstrated that over a 8-year period in the province of Saskatchewan, the age-standardized incidence rate of dementia declined among individuals aged 45 and older while the age-standardized prevalence rate simultaneously increased. These trends indicate that the average survival time with dementia was also increasing, suggesting the possibilities that recognition of dementia is taking place in earlier stages and treatment is improving. As individuals live longer with dementia, similar to other chronic diseases, they require active care and monitoring for an extended period of time (Bergman, 2009; Alzheimer's Disease International, 2014). To spur improvements in dementia care and address increasing cost burdens, several G7 nations have developed national dementia strategies (France, Japan, United Kingdom, United States, Italy). Canada currently does not have a national dementia plan, despite an estimated 500,000 Canadians living with dementia in 2008 and over 100,000 incident cases developing

each year (Dudgeon, 2010). Further reduction in dementia incidence is certainly possible with the type of concentrated focus that a national strategy promises, and future research should track these developments.

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