Journal of Alzheimer's Disease xx (20xx) x–xx
DOI 10.3233/JAD-180375
IOS Press

Secular Trends in Dementia Prevalence and Incidence Worldwide: A Systematic Review

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Accepted 23 August 2018

Abstract.
Background: Time trends for dementia prevalence and incidence rates have been reported over the past seven decades in different countries and some have reported a decline.
Objective: To undertake a systematic review to critically appraise and provide an evidence-based summary of the magnitude and direction of the global changes in dementia prevalence and incidence across time.
Methods: Medline, EMBASE, and PsychINFO were searched for studies focused on secular trends in dementia prevalence and/or incidence until 18 December 2017. In total, 10,992 articles were identified and 43 retained.
Results: Overall, prevalence rates are largely increasing (evidence primarily from record-based surveys and cohort studies in Japan, Canada, and France) or have remained stable (evidence primarily from cohort studies in Sweden, Spain and China). A significant decline in prevalence has however been reported in more recent studies (i.e., from 2010 onwards) from Europe (e.g., UK and Sweden) and the USA. Incidence rates have generally remained stable or decreased in China, Canada, France, Germany, Denmark, Sweden, the Netherlands, UK, and USA. An increase has only been reported in five countries: Italy, Japan, Wales, Germany, and the Netherlands. Only one study reported findings (stability in incidence) from a low and middle-income country using data from Nigeria.
Conclusions: The evidence on secular trends in the prevalence and incidence of dementia is mixed including contradictory findings using different (and in some cases the same) datasets in some countries (e.g., the USA, UK, and Sweden). This making it difficult to draw concrete conclusions. However, declining trends recently observed in some high-income Western countries in the most recent two decades including the UK, USA, and Sweden are encouraging. Updated dementia prevalence and incidence estimates will inform public health and financial planning as well as development of prevention strategies.

Keywords: Dementia, incidence, prevalence, secular trends, systematic review

INTRODUCTION

Dementia is a global health concern. In 2015, it was estimated that there were 47 million people with dementia worldwide, and this number is predicted to increase to 75 million by 2030 [1]. However, recent evidence suggests, at least in some countries, that

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ISSN 1387-2877/18/$35.00

the risk of dementia is changing and even declining [2–5]. Population-level public health strategies and improved clinical management of key modifiable risk factors such as smoking, low educational attainment and cardiovascular disease are putative drivers of the declining trends.

However, not all studies have reported declining (or stable) trends in dementia prevalence or incidence rates. Heterogeneous findings may be due to differences in study methodology (e.g., time periods investigated, changes in dementia diagnostic criteria over time) as well as economic transitions resulting in changes in population health status (e.g., increasing obesity rates), improved risk factor management (e.g., hypertension), differences in survival (e.g., from stroke and with dementia), improved public health and awareness of dementia, or higher educational attainment (e.g., cognitive reserve). Knowing changes in population risk of dementia has implications for calculating future projections used for anticipating health care needs, estimating costs, and budgeting resources. Current estimates are usually based on the assumption that dementia prevalence and incidence rates are stable over time and, in light of recent findings, calculations using this method may be incorrect [6].

We therefore sought to determine whether rates of dementia have changed over time by conducting a systematic review of studies which have investigated historical or recent secular trends in dementia prevalence or incidence rates.

METHODS

Search strategy

This systematic review was conducted adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: PRISMA guidelines [7]. Embase, Medline, and PsychINFO were searched with the terms "dementia", "epidemiology", "prevalence", and "incidence" (see Supplementary Material 1). All languages and dementia sub-types were included. The initial search was conducted on the 27 January 2015. Updated searches were run from January 2015 to 22 July 2016 and again from 22 July 2016 to 18 December 2017.

Inclusion/exclusion criteria

All population-based studies reporting dementia prevalence or incidence rates, across similar populations separated by time were eligible for inclusion. No restriction was applied to the setting from which the cohorts were derived (e.g., community, care home, or residential home) provided that comparison was being made between cohorts from similar backgrounds (e.g., location, socio-demographic status). Studies were required to have based their diagnosis of dementia or its subtypes on validated criteria (e.g., Geriatric Mental State Examination, Diagnostic and Statistical Manual of Mental Disorders (DSM), or International Classification of Diseases criteria). Other methods for the diagnostic assessment of dementia such as the use of cognitive test scores (e.g., Clinical Dementia Rating (CDR) Scale or Mini Mental State Examination (MMSE)) or via record review, were also allowed provided the study had evidenced the presence of standardization in their choice. Exclusion criteria included: 1) studies where dementia prevalence and/or incidence were reported in a single cohort only, with no time trends; and 2) studies where the sample was restricted to participants aged $\leq$60 years in order to focus on late-life rather than early onset dementia which is relatively rare, often has a different presentation, and has, in some cases, been associated with genetic abnormalities [8]. Studies were not excluded if the diagnostic criteria for dementia changed across time; the limitations of such studies will be discussed separately.

Data analysis

Three investigators (EYHT, MS, RB) independently searched publications for inclusion. Titles and abstracts were searched first, followed by the full text of identified articles. Reviews were also retained and the reference lists of these and each included paper interrogated. Where multiple publications using the same study were identified, these were retained for full text review. Disagreements were resolved by consensus or discussion with a third investigator (BCMS or LR). Data were independently abstracted by three investigators (EYHT, RB, TDC) and checked by a third (BCMS). Due to considerable methodological variation, no meta-analysis was performed. Instead, figures were produced to show the time trends in dementia prevalence and incidence reported across the studies based on statistical significance of the results. Also, see Supplementary Material 2 for the reported rates over time and statistical results where trends have been tested.

Role of the funding source

Preparation of the results for publication was completed as part of the NIHR Global Group: DePEC (Grant number: 16/137/62). BCMS has full access to the data and had final responsibility to submit for publication.

RESULTS

As shown in Fig. 1, the electronic search returned 15,126 articles, of which 10,992 were retained after removing duplicates. Following the title/abstract search, 90 articles were selected for full text review. Of these, six presented data from the Rochester Epidemiology Project (Minnesota, USA) [9–14], six presented data from the Japanese Hisayama Study [15–20], three presented data from the National Long-Term Care Survey (NLTCS, USA) [21–23], and two presented data from Daisen-cho (Japan) [24, 25]. Of the six Rochester articles, one presented unique findings on prevalence [9] and the other on incidence [14] and both were retained. Of the six Hisayama Study articles, three reported time trends in prevalence: one [17] over seven years follow-up (1985 versus 1992), one [18] over 20 years follow-up (1985, 1992, 1998, and 2005), and one [19] over 29 years follow-up but only using the neuropathology data. The most recent paper [20] reported time trends in prevalence (1985, 1992, 1998, 2005, and 2012) and incidence (1998 versus 2002 cohorts) and was retained. Two articles utilizing data from the NLTCS were retained as they covered unique time periods [21, 23]. Only one article [25] was retained from the study in Daisen-cho (Japan) as it included data from the previous publication. One article [14] synthesized findings in time trends of incidence and prevalence of cognitive impairment and dementia from different studies across the USA. This was retained as it included unique (incidence) data from the Rochester Study; two other relevant studies reported in this article had been identified in the electronic search and were included separately [26, 27]. From the full text review, a further 28 articles [28–55] presented unique findings on time trends in prevalence and/or incidence and were included. Six articles [56–61] were identified from other sources and were also retained. The full text of one potential article [62], identified from a systematic review [63], could not be located. Therefore, 43 articles are included. Most studies used samples representative of the population of interest (see Tables 1 and 2).

Of the 43 articles, 18 [9, 21, 23, 25, 26, 31, 32, 34, 38–40, 45, 50, 53–55, 58, 61] included time trends in prevalence, 17 [14, 27, 28, 33, 35–37, 42, 44, 46, 47, 49, 51, 52, 59, 60, 64] included time trends in incidence, and 8 [20, 29, 30, 41, 43, 48, 56, 57] included time trends in both prevalence and incidence. Tables 1 and 2 summarize the design, methods, and key findings from the prevalence and incidence studies, respectively. Studies varied in the data resources used (health data/record review versus cohort studies), period of assessment (earliest baseline 1947 [41] versus latest baseline 2011 [52]), length of time between comparison studies (range: 3 to >20 years), outcome (all cause dementia, Alzheimer's disease (AD), and vascular dementia (VaD)) and sample age (entire age range versus restricted to the older aged population).

Prevalence studies

Of the 26 studies reporting time trends in prevalence most were conducted in the USA ($n = 5$ [9, 21, 23, 26, 50]) and Sweden ($n = 5$ [32, 34, 38, 39, 41]), followed by Canada ($n = 4$ [40, 48, 57, 58]), France ($n = 3$ [29, 53, 56]), Japan ($n = 3$ [20, 25, 61]), China ($n = 2$ [30, 45]), the UK ($n = 2$ [43, 55]), and one study each in Germany [54] and Spain [31]. Nine studies [9, 21, 23, 40, 48, 54, 56–58] used data from medical record, health and health care utilization databases and 17 [20, 25, 26, 29–32, 34, 38, 39, 41, 43, 45, 50, 53, 55, 61] used cohort study data. Two studies [20, 30] did not maintain consistency in diagnostic criteria across time and used updated criteria at the later time point.

Record-based studies

As shown in Fig. 2, the earliest record-based study captured the time period 1975 to 1985 (USA) and reported mixed findings; stability in prevalence 1975 to 1980 and a significant increase 1980 to 1985 [9]. Five further studies also reported significant increases in dementia prevalence including studies in: The USA (1984–1990 to 1991–2001: With the increase more marked for AD than VaD and senile dementia [not AD or VaD]) [23], France (2004–2010) [56], and three studies in Canada (Alberta: 1998–2009 [40], Saskatchewan: 2005–2006 to 2012–2013 [48], and Ontario: 2004–2005 and 2010–2011 [57]). One study in Canada (British Columbia: 2001–2002 to 2007–2008) reported an increase in dementia prevalence but the time trend was not tested statistically [58]. The remaining two studies reported significant decline in prevalence including one study based in

Table 1
Details of included studies (arranged by baseline year): Prevalence findings

Reference	Country	Data Source	Population Representative	Age (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Rorsman [41]	Sweden, Lundby	Lundby Study	Yes	≥60	1947–1957 versus 1957–1972	Dementia (including senile and multi-infarct). DSM-III	Age-standardized	- Stable (both senile and multi-infarct dementia)	Stable	Age-standardized prevalence of senile dementia has decreased in the higher age groups while multi-infarct dementia has increased	For both sexes, prevalence figures were similar across the two time periods (for both senile and multi-infarct dementia)
Beard [9]	USA, Rochester	Medical Record Information: Rochester Epidemiological Project	Yes	Whole population	1975 versus 1980 versus 1985	Dementia. Documented evidence/ record review	Age and sex-specific	- Stable 1975 to 1980 - Sig increase 1980 to 1985	Mixed	Increase with age for both sexes; greatest in the oldest-old	No differences in age-adjusted rates by sex
Wiberg [38]	Sweden, Gothenburg	H70 studies	Yes	70 and 75	1976/77 versus 2000/01 versus 2005/06	Dementia. Kay et al 1964 criteria	GLM controlling for age, sex, year	- No sig difference at ages 70 or 75 years	Stable	NR	NR
Wakutani [25]	Japan, Daisen-cho	Epidemiological Studies of the total population of Daisen-cho	Yes	≥65	1980 versus 1990 versus 2000	Subjective report (1st stage) followed by documentary search and clinical assessment of possible cases (Stage 2). Dementia, AD, and VaD. DSM-III and Hachinski Ischemic Score	Age-specific	- Increase in dementia and AD rates. In terms of severity increases have been mainly in mild versus severe-moderate cases - J-shape VaD ***No statistical test of trends	Mixed	NR	NR

Ukraintseva [23]	USA, nationally representative	National Long Term Care Surveys (NLTCS)	Yes	≥65	1984 to 1990 versus 1991 to 2001	Dementia, Senile dementia (not AD or VaD), AD, and VaD. ICD-9-CM	Age-specific	- Sig increase in dementia - Most pronounced absolute increase in AD, increases in VaD and senile dementia less pronounced - Stable senile dementia	Increase	NR	NR
Suzuki [61] Article in Japanese	Japan, Tokyo	Toyama Prefecture, urban and rural sites	Yes	≥65	1985 versus 1990 versus 1996 versus 2001	Dementia, AD and VaD. ICD-10 (in addition to Hachinski Ischemic Score, HDS-R and Mini-Dementia Scale)	Age and sex adjusted	- Sig increase in dementia (trend of an increase in AD and VaD)	Increase	Sig increases in rates of dementia and AD in ≥85-year-olds	In males, the population of VaD (%) is higher than AD in 1985, 1990, and 1996, whereas in 2001 AD is slightly higher than VaD. In females, AD accounts for almost the majority of dementia

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Table 1
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Reference	Country	Data Source	Population Representative	Age (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Ohara [20]	Japan, Hisayama	Hisayama Study	Yes	≥65	1985 versus 1992 versus 1998 versus 2005 versus 2012	Dementia, AD, VaD, and other dementia. DSM-III (1985) and DSM-III-R (1992 onwards). Karasawa's criteria (all-cause) and Hachinski score (AD versus VaD) ***Different criteria used across time	Age and sex-specific	- Sig increase in dementia and AD - No sig difference in VaD (J-shape) or other dementia	Mixed	Sig increase over time among ≥70 years (Dementia) and ≥75 years (AD)	Similar trends observed for dementia and its subtypes for both sexes
Yan [45] Article in Chinese	China, Beijing	Cohort study in the urban district of Beijing	Yes	≥65	1986 versus 1997 versus 2004	Dementia. ICD-10	Rate reported by age and sex	- No sig change (moderate and severe dementia) - In 2004 AD much higher than VaD	Stable	Diagnosis rates increased with age	No sig sex effect
Li [30]	China, Beijing	Cohort study	Yes	>60	1986–89 versus 1997–99	Dementia, AD, VaD. Modified DSM-III (1st study) and ICD-10/DSM-IV (2nd study). The dementia differential diagnostic scale (WHO 1985 version) and Hachinski Ischemic Index used for AD versus VaD	Age-specific	- Non-sig increase in rates of all cause dementia - ratio of AD to VaD changed (AD became more common)	Stable	Rates increased with age at both time points (no age by cohort interaction tested)	NR

						***Different criteria used across time and different MMSE cut-offs used for screening across studies					
Qiu [34]	Sweden, Stockholm	Kungsholmen Project and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K)	Yes	≥75	1987–94 versus 2001–08	Dementia. DSM-III-R	Age and sex-specific	- No sig difference in rate of dementia	Stable	Similar age-specific prevalence rates	No sex differences (generally higher prevalence in women than men aged ≥85 years)
Lobo [31]	Spain, Zaragoza	Zaragoza Study (ZARADEMP-0 and ZARDEMP-1)	Yes	≥65	1988–89 versus 1994–96	Dementia. DSM-IV	Age and sex-specific	- No sig difference in rates of all cause dementia	Stable	Sig decline in men between 70–84 years	Sig decline in men only
Peres [53]	France, Gironde	Personnes Agées QUID (PAQUID) and the Aging Multidisci-plinary Investigation (AMI) Study	No	≥65	1988/89 versus 2007/08	Stepwise consensus approach: MMSE/ADL items, DSM-III-R (neuropsy-chologist), then consensus conference	Age and sex-adjusted	- Sig increase	Increase	NR	NR
Grasset [29]	France, Bordeaux	Personnes Agées QUID (PAQUID) and the 3-City Study	Yes	≥65	1988/89 to 1998/99 (1990s) versus 1999/01 to 2009/10 (2000s)	Dementia. Algorithmic (incorporating MMSE and IADL) versus Clinical (DMS-II-R and DSM-V)	Crude	-Increase (clinical diagnosis) -Decrease (algorithmic diagnosis) ***No statistical test of trends reported	Mixed	NR	NR

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Table 1
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Reference	Country	Data Source	Population Representative	Age (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Matthews [55]	UK	Cognitive Function and Ageing Studies (CFAS)	Yes	≥65	1989–94 versus 2008–11	Dementia. AGECAT	Age and sex-specific	- Sig decrease	Decrease	Decline primarily in the >80 years age group	Consistently higher prevalence in women than men
Hall [26]	USA, Indianapolis (African Americans)	Indianapolis-Ibadan Dementia Project ***Different methods of recruitment at the two time periods	No	≥70	1992 versus 2001	Dementia (DSM-III-R and ICD-10), AD (NINCDS/ ADRDA), VaD or other secondary dementias (i.e., alcohol related dementia, Parkinson's Disease) (ICD-10)	Age-specific	- No sig difference in rates of dementia, AD, VaD, or other secondary dementias	Stable	NR	NR
Manton [21]	USA, Nationwide	National Long Term Care Surveys (NLTCS) from the Medicare enrolment lists	Yes	≥65	1994 versus 1999	Dementia and AD. Medicare record physician determined diagnosis of VaD, mixed, and AD. ICD-9	Age-specific	- Sig decline in mixed dementia - Non-sig increase in AD	Mixed	At >80 years sig decline in mixed dementia in men, non-sig decline in women. No change in AD for men and women aged ≥80 years	Sig decline in mixed dementia in men, non-sig decline in women

Wimo [39]	Sweden, Nordanstig (rural samples)	Nordanstig Project (NP) and the Swedish National Study on Ageing and Care in Nordanstig (SNAC-N)	Yes	≥78	1995–98 versus 2001–03	Dementia. DSM-III-R	Age and sex adjusted	- Sig reduction	Decline	NR	Sig decrease in men
Jacklin [40]	Canada, Alberta	Alberta Health Physician Claims Data (Provided by Alberta Health and Wellness)	No	Whole population	1998 to 2009 (yearly)	Treated for dementia. At least one physician visit with a primary diagnosis of dementia or AD (ICD-9)	Age-specific	- Increase (Significantly higher rise over time in First Nations compared to non-First Nations, primarily after 2006) ***No statistical test of trends for whole population or by group. Only the interaction term (group by time) reported	Increase (First Nations)	Younger age profile in First versus non-first Nations	Sig sex differences: Higher rates in females (non-First Nations) and higher rates in males (First Nations)
Langa [50]	USA, Nationwide	Health and Retirement Study	Yes	≥65	2000 versus 2012	Dementia. Aging, Demographics and Memory Study (ADAMS) dementia diagnosis	Age and sex-specific	- Sig decrease	Decrease	Sig increase risk of dementia with increased age	No sex differences

(Continued)

Table 1
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Reference	Country	Data Source	Population Representative	Age (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Mathillas [32]	Sweden, Umea	Umea 85 + and the GEronto-logical Regional Database (GERDA)	Yes	≥85	2000–02 versus 2005–07	Dementia, AD and VaD. DSM-IV	Controlled for age and sex	- Sig increase in dementia rates - No difference in the proportion of AD to VaD cases between time periods	Increase	Sig age-specific increase among 85- and 90-year-olds (no sig differences in >95 age group)	Sig increase in women, not men
Fang [58]	Canada, British Columbia	British Columbia Ministry of Health Services healthcare utilization data	Yes	65+	2001/02 to 2007/08 (yearly)	Dementia. One hospitalization or two medical claims coded ICD-9 (290) or ICD-10 (F00-F03) within 365 days	Age-specific	- Increase ***No statistical test of trends	Increase	Age-standardized rates lower than crude rates	NR
Ahmadi-Abhari [43]	UK, Multi-site	English Longitudinal Study of Ageing	Yes	≥50	2002 to 2013	Dementia. Cognitive (IQCODE) and functional (difficulty in performing ≥ADL) impairment or self-reported doctor diagnosis; definition conforms to DSM-IV criteria	Age and sex-specific	- Sig decrease	Decrease	NR	NR

Bertrand [56]	France, Nationwide	French National Health Care Insurance Plan Database (Echantillon Generaliste des Beneficiaries: EGB)	Yes	≥65	Annual 2004 to 2010	Dementia. Taking anti-dementia drug or 100% reimbursed for health care related to dementia (ICD-10)	Age and sex-specific	Sig increase	Increase	Interaction with age: Increase in rate between 70–74 versus ≥90 years for both men and women (no stats results reported)	Overall higher in women than men (no stats results reported)
Ng [57]	Canada, Ontario	Health Administrative Data	Yes	≥40 and ≥66	2004/05 to 2010/11 (yearly)	Younger than 66 years: 1 hospitalization record or 3 physician claim records at least 30 days apart in a 2-year period 66 years and older: 1 hospitalization record or 3 physician claim records at least 30 days apart in a 2-year period or 1 prescription drug reimbursement record	Age and sex-specific	**≥40 years** - Sig increase (non-overlapping confidence intervals) **≥66 years** - Sig increase (non-overlapping confidence intervals)	Increase	Different trends depending on age (no stats results reported)	Higher rates in females (increases in prevalence in both males and females) (no stats results reported)

(Continued)

Table 1
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Reference	Country	Data Source	Population Representative	Age (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Kosteniuk [48]	Canada, Saskatchewan	Provincial Administrative Health Databases	Yes	≥45	2005/06 versus 2012/13	Dementia. Different depending on database but included: ICD-9, ICD-10-AC, ≥1 prescription for a cholinesterase inhibitor, Cognitive Performance Scale Score and/or a disease category of AD or non-AD dementia	Age-specific	- Sig increase	Increase	Sig increase apparent in every age group for both sexes (largest increment in the 55–64 age group and smallest in the ≥85 age group)	Sig increase in both sexes (slightly larger in males than females)
Doblhammer [54]	Germany	Public health insurance company data Allgemine Ortskrankenkasse: AOK	No	≥65	2007 versus 2008 versus 2009	Dementia. ICD-10	Age-specific	- Sig decrease (women only) - Stable in men (trend for a decrease, but not sig)	Mixed	Sig reduction in women aged 75–84 years	Sig decline in women, not sig in men

Key: ACT, The Anatomical Therapeutic Chemical Classification System; AD, Alzheimer's disease; ADL, Activities of Daily Living; AGECAT, Automated Geriatric Examination for Computer Assisted Taxonomy; DSM-III, Diagnostic & Statistical Manual of Mental Disorders, Third Edition; DSM-III-R, Diagnostic & Statistical Manual of Mental Disorders, Third Edition (Revised); DSM-IV, Diagnostic & Statistical Manual of Mental Disorders, Fourth Edition; GLM, General Linear Model; GP General Practitioner; HDS-R, Hasegawa Dementia Rating Scale-Revised; ICD-9, International Classification of Diseases, Ninth Revision; ICD-9-CM, The International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10, The International Classification of Diseases, Tenth Revision; ICD-10-CM, The International Classification of Diseases, Tenth Revision, Clinical Modification; MMSE, Mini-Mental State Examination; NIA AD, The National Institutes of Health Alzheimer's disease criteria; NINCDS ADRDA, National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association criteria; NINDS-AIREN, National Institute of Neurological Disorders and Stroke and Association Internationale pour la Recherché criteria; NR, Not reported; sig, Significant; VaD, vascular dementia; WHO, World Health Organization; y, years.

Table 2
Details of included studies (arranged by baseline year): Incidence findings

References	Country	Data Source	Population Representative	Age Range (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Rorsman [41]	Sweden, Lundby	Lundby Study	Yes	≥60	1947–57 versus 1957–72	Dementia (including senile and multi-infarct). DSM-III	Age-standardized	- Stable (both senile and multi-infarct dementia)	Stable	NR	NR
Sauvaget [46]	USA, Northern California	Kaiser Permanente Medical Care Program-Northern California	No	≥65	1971–79 versus 1980–88	Dementia. ICD-9	Age-specific	- No sig cohort differences	Stable	Men aged 70–74 years had a 3-fold higher risk of dementia at the later time point. While women ≥85 years had a 1.5 times higher rate in the later born cohort.	Similar rates observed for both sexes in each cohort
Sacuiu [35]	Sweden, Gothenburg	Cohort study	Yes	70–75	1971–72 versus 2000-01	Dementia. Historical criteria (Cohort 1) and DSM-III-R (Cohort 2). ***Different criteria used across time	Unadjusted (Note: samples aged 70 years)	- No sig cohort differences in rates of dementia	Stable	N/A	Men sig more likely to have dementia (Period 1), no sex difference (Period 2)
Rocca [14]	USA, Rochester	Rochester Epidemiology Project	Yes	≥70	1975 to 1994	Dementia and AD. Record review, like DSM III-R and NIH AD criteria ***Number of codes changed over time	Age-specific	- Stable over 20 years - Sig decline (dementia and AD) only between in 1985-94	Mixed (When the time tested was 1975 to 1994 the overall trend was stable)	Some evidence of declining trend in the 80-84, 85-89, and 90-94 years age groups	No consistent sex pattern observed

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Table 2
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References	Country	Data Source	Population Representative	Age Range (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Satizabal 2016 [36]	USA, Framingham	Framingham Heart Study	Yes	≥60	1977-83 versus 1986-91 versus 1992-98 versus 2004–08	Dementia, AD, VaD. DSM-IV, NINCDS-ADRDA (for AD), NINDS-AIREN (VaD)	Hazard Ratios (age and sex adjusted)	- Sig decrease in dementia (only in the high education group) - Sig decrease in VaD - No sig difference in AD	Mixed	No interaction between time and age (sig increase in mean age of diagnosis from 80 to 85 years)	No interaction between time and sex
Li 2007 [30]	China, Beijing	Cohort study	Yes	≥60	1986–89 versus 1997–99	Dementia. Modified DSM-III (1st study) and ICD-10/DSM-IV (2nd study). The dementia differential diagnostic scale (WHO 1985 version) and Hachinski Ischemic Index for AD versus VaD ***Different criteria used across time and different MMSE cut-offs used for screening across studies	Age-specific	- No sig difference in rate of all cause dementia (but, AD became more common than VaD)	Stable	NR	NR
Ohara 2017 [20]	Japan, Hisayama	Hisayama Study	Yes	≥65	1988/89 versus 2002–2012	Dementia, AD, VaD. DSM-III (1985), DSM-III-R (1992, 1998, 2005, 2012). AD (NINCDS-ADRDA) and VaD (NINDS-AIREN) ***Different criteria used across time	Age and sex-adjusted	- Sig increase dementia and AD - No sig difference VaD or other/unspecified dementia	Mixed	Sig increase dementia and AD in the 65–84 years but not ≥85 years group	Similar trend all-cause dementia (both sexes) AD 3.0-fold men and 1.9-fold women

Grasset [29]	France, Bordeaux	Personnes Agées QUID (PAQUID) and the 3-City Study	Yes	≥65	1988/89 to 1998/99 (1990s) versus 1999/01 to 2009/10 (2000s)	Dementia. Algorithmic (incorporating MMSE and IADL) versus Clinical (DMS-II-R and DSM-V)	Age-specific	- No sig difference (clinical diagnosis) - Sig decline overall and in women (algorithm diagnosis)	Mixed (Depending on diagnostic method)	NR	No sex differences based on clinical diagnosis. Sig decline in women (algorithm diagnosis only), but stable in men
Matthews [33]	UK, Multicenter	Cognitive Function and Ageing Studies (CFAS)	Yes	≥65	1989–94 versus 2008–11	Dementia. AGECAT	Age and sex-specific	- non sig decline	Stable	Decline in all age groups	Sig decrease in men but not women
Schrijvers [37]	The Netherlands, Rotterdam	Rotterdam Study	Yes	60–90	1990–95 versus 2000–05	Dementia. DSM-III-R	Age-specific	- No sig difference	Stable (trend of a decrease over time)	Non-sig decline across all age strata (60–69, 70–79, 80–89)	No sig sex differences
Gao [28]	USA, Indianapolis (African Americans)	Cohort study	No	≥70	1992–09 versus 2001–09	Dementia and AD by consensus diagnostic conference. DSM-III-R and ICD-10. NINCDS-ADRDA (for AD)	Age-specific	- Sig decrease (dementia and AD)	Decrease	Sig lower age-specific rate in all age groups except ≥85 years (dementia) and ≥80 years (AD)	NR
Gao [28]	Nigeria, Yoruba in Ibadan	Cohort study	Yes	≥70	1992–09 versus 2001–09	Dementia and AD by consensus diagnostic conference. DSM-III-R and ICD-10. NINCDS-ADRDA (for AD)	Age-specific	- No sig differences (dementia and AD)	Stable	No age effects	NR

(Continued)

Table 2
(Continued)

References	Country	Data Source	Population Representative	Age Range (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Noble [60]	USA, Northern Manhattan	Washington Heights-Inwood Columbia Aging Project	Yes	65–86	1992–03 versus 1999–13 ***Slight differences in recruitment protocol 1992 versus 1999 cohort	Dementia. DSM-IV	Hazard Ratio (controlling for age, sex, education, memory complaint, ethnicity, smoking and disease comorbidity)	- Sig decline (total sample; greatest among non-Hispanic Whites ad African Americans. Lowest among Hispanics)	Decrease	NR	Greatest reduction in those aged ≥75 years
Van Bussel [49]	The Netherlands, Nationwide	General Practice Registration Networks (GPRNs)	Yes	≥60	1992–2014	Senile dementia/AD. International Classification of Primary Care Code P70	Rate ratio (controlling for age and sex)	- Sig increase	Increase	Sig increase in all ages (similar trends in all age groups)	Similar trends for both sexes (but overall higher rates in women than men)
Derby [51]	USA, Bronx County	Einstein Aging Study	Yes	≥70	1993 to 2015	Dementia. DSM-IV	Age-specific	- Sig decrease	Decrease	NR	Decreasing incidence within each age group over time
Hebert [27]	USA, Chicago	Chicago Health and Aging Project	Yes	≥65	1997 to 2008	AD. NINCD-ARDRA	Odds Ratio	- No sig difference in rates of AD	Stable (point estimate direction of decline but not sig)	No age interaction	No sex interaction
Pierri [42] Article in Italian	Italy, Brindisi Provience (data standardised to the Italian population)	Record Review	Yes	≥65	1998, 1999, and 2000	Dementia. ICD-10	Not specified	- Increase	Increase	NR	NR

Abdulrahman [59]	Wales, Nationwide	Patient Episode Database	Yes	≥60	1999 to 2010 (yearly)	AD. ICD-10 (G300, G301, G308, G309)	Age stratified	***No statistical test of trends - Sid decline (2000), stable (2001), sig increase (2002) stable 2003), sig increase (2004–2010)	Mixed	NR	Relatively stable in the 60–74 years age group, but increasing progressively in people aged ≥75 (no statistical test)
Jorgensen [64]	Denmark, Nationwide	Danish Civil Registration System, Danish National Patient Registry, Danish National Prescription Registry and the Income Statistics Registry	Yes	≥65	2000 to 2009	AD. AD medication ACT code: N06DA02, N06DA03, N06DA04, N06DX01) or first AD diagnosis (ICD-10)	Age stratified	**65–74 years** - Mixed (sig increase 2000–02 and stable 2002–09) **>75 years** - Mixed (sig increase 2000–03 and stable 2003–09)	Mixed	Different time trends across age groups	NR
Ahmadi-Abhari [43]	UK, UK, Multi-site	English Longitudinal Study of Ageing	Yes	≥50	2002 to 2013	Dementia. Cognitive (IQCODE) and functional (difficulty in performing ≥ADL) impairment or self-reported doctor diagnosis; definition conforms to DSM-IV criteria	Age and sex-specific	- Sig decrease (sig for both men and women)	Decrease	N/A	Reduction steeper in women versus men (but not sig different)

(Continued)

Table 2
(Continued)

References	Country	Data Source	Population Representative	Age Range (y)	Time Periods	Outcome and Criteria	Measure	Specific Findings	Overall Findings	Age-specific Findings	Sex-specific Findings
Sposato [47]	Canada, Ontario	Ontario Health Insurance Plan, Ontario Drug Benefit Database, Discharge Abstract Database and the National Ambulatory Care Reporting System	Yes	≥20	2002 to 2013 (yearly)	Dementia. Different across datasets: 1 hospitalization with any field diagnosis of dementia, 1 physician visit with a diagnosis of dementia, or 1 prescription of a cholinesterase inhibitor within the previous year	Age and sex-standardized	- Sig decrease	Decrease	N/A	N/A
Ng [57]	Canada, Ontario	Database: Health Administrative Data	Yes	>40	2004/05 to 2010/11 (yearly)	Younger than 66 years: 1 hospitalization record or 3 physician claim records at least 30 days apart in a 2-year period 66 years and older: 1 hospitalization record or 3 physician claim records at least 30 days apart in a 2-year period or 1 prescription drug reimbursement record	Age and sex-specific	**≥40 years** -Trend of a decrease (not sig; overlapping confidence intervals) **≥66 years** - Trend of a decrease (not sig; overlapping confidence intervals)	Stable	Similar tends in both age groups	NR
Bertrand [56]	France, Nationwide	French National Health Care Insurance Plan Database (Echantillon Generaliste des Beneficiaries: EGB)	Yes	≥65	Annual 2004 to 2010	Dementia. Taking anti-dementia drug or 100% reimbursed for health care related to dementia (ICD-10)	Age and sex-specific	No sig trend in number of new cases	Stable	NR	NR

Kosteniuk [48]	Canada, Saskatchewan	Provincial Administrative Health Databases	Yes	≥45	2005/06 versus 2012/13	Dementia. Different depending on database but included: ICD-9, ICD-10-CA,≥1 prescription for a cholinesterase inhibitor or a Cognitive Performance Scale Score and/or a disease category of AD or non-AD dementia	Age-specific	- Sig decline	Decrease	No overall age effect. But sig decline in old-old age groups in women and sig decline in men 65–74 years	Sig decline in women (not men)
Doblhammer [44]	Germany, Nationwide	Allgemeine Ort-skrankenkasse: AOK (Public health insurance data)	No	≥65	2006/07 to 2009/10	Dementia. ICD-10 or prescription for anti-dementia drugs	Age-specific	- Sig decrease	Decrease	Trend (not sig) of an increase in mean age of diagnosis for both men and women	Sig decline in both women and men
Bohlken [52] Article in German	Germany, Multi-site	Disease Analyser Database (IMS Health). Data included from GP practices and neuropsychi-atric specialist services	Yes	≤70 to >90	2011 to 2015	Dementia, AD, VaD, and non-specific dementia. ICD-10	Age and sex controlled in analyses	- Sig increase (GP data; mainly due to increases in VaD and non-specific dementia. Proportion with AD remained constant) - Stable (specialist services)	Mixed (depending on data resource)	NR	NR

Key: ACT, The Anatomical Therapeutic Chemical Classification System; AD, Alzheimer's disease; ADL, Activities of Daily Living; AGECAT, Automated Geriatric Examination for Computer Assisted Taxonomy; DSM-III, Diagnostic & Statistical Manual of Mental Disorders, Third Edition; DSM-III-R, Diagnostic & Statistical Manual of Mental Disorders, Third Edition (Revised); DSM-IV, Diagnostic & Statistical Manual of Mental Disorders, Fourth Edition; GLM, General Linear Model; GP General Practitioner; HDS-R, Hasegawa Dementia Rating Scale-Revised; ICD-9, International Classification of Diseases, Ninth Revision; ICD-9-CM, The International Classification of Diseases, Ninth Revision, Clinical Modification; ICD-10, The International Classification of Diseases, Tenth Revision; ICD-10-CM, The International Classification of Diseases, Tenth Revision, Clinical Modification; MMSE, Mini-Mental State Examination; NIA AD, The National Institutes of Health Alzheimer's disease criteria; NINCDS ADRDA, National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association criteria; NINDS-AIREN, National Institute of Neurological Disorders and Stroke and Association Internationale pour la Recherché criteria; NR, Not reported; sig, Significant; VaD, vascular dementia; WHO, World Health Organization; y, years.

the USA (1994–1999) [21] and the other in Germany (2007–2009: Women only with little change in the total sample) [54].

Cohort studies

As shown in Fig. 2, of the 17 cohort studies, four reported a significant increase in prevalence including studies in: Japan (1985–2001 in dementia [61] and 1985–2012 in dementia and AD only, not VaD or other/unclassified dementia [20]), France (1988–1990 versus 2007–2009) [53], and Sweden (Umea [70- and 75-year-olds only]: 2000–2002 versus 2005–2007, no significant difference in the proportion of AD to VaD between time periods) [32]. A further study, based in Japan (rural area), reported a trend of an increase in the prevalence of dementia and AD (mainly in mild versus moderate/severe cases and a J-shape trend in VaD prevalence: 1980, 1990, and 2000) [25]. However, in this study changes in rates over time were not statistically tested. In contrast, three studies reported a significant decline in prevalence including studies in Rural Sweden (Nordanstig: 1995–1998 versus 2001–2003, total sample and men only) [39], the UK (1989–1994 versus 2008–2011) [55], and the USA (2000–2012) [50]. One study from France (Bordeaux: 1990s versus 2000s) also reported a decline, but the rate of change was not statistically tested [29]. Eight studies reported no significant changes across time including studies in: Sweden (Gothenburg: 1976–1977, 2000–2001, and 2005–2006 [38]; Lundby (senile and multi-infarct dementia): 1947–1957 versus 1957–1972 [41] and Stockholm: 1987–1994 versus 2001–2004) [34]), China (Beijing: 1986–1989 versus 1997–1999 [30] and 1986–2004 [45]), Spain (1988–1989 versus 1994–1996; significant reduction in men only) [31], the USA (1992 to 2001, African Americans only and including all cause, AD, and other dementia disorders) [26] and the UK (2002–2003 to 2012–2013) [43].

Incidence studies

Of the 25 studies reporting time trends in incidence, most were conducted in the USA ($n = 7$ [14, 27, 28, 36, 46, 51, 60]), followed by Canada ($n = 3$ [47, 48, 57]), France ($n = 2$ [29, 56]), the Netherlands ($n = 2$ [37, 49]), Sweden ($n = 2$ [35, 41]), UK ($n = 2$ [33, 43]), Germany ($n = 2$ [44, 52]), and one study each in Nigeria [28], Denmark [64], Wales [59], Italy [42], Japan [20], and China [30]. Twelve studies [14, 42, 44, 46–49, 52, 56, 57, 59, 64] used data from medical record, health and health care utilization databases and thirteen studies [20, 27–30, 33, 35–37, 41, 43, 51, 60] used cohort data. Four studies [14, 20, 30, 35] did not maintain consistency in diagnostic criteria across time.

Record-based studies

As shown in Fig. 3, four studies reported an increase in incidence of dementia including studies from: Italy [42] (1998–2000: but, the trend was not statistically tested), the Netherlands [49] (1992–2014: the increase while statistically significant was small, i.e., 2.1%), Wales [59] (relatively stable 1999–2003 and significant increase 2004–2010), and Germany [52] (2011–2015 based on General Practitioner data; relatively stable 2011–2012 and significant increase 2013–2015, mainly driven by increases in VaD and non-specific dementia with a relatively stable trend in AD). In contrast, three studies reported a significant decrease in incidence including two in Canada (Ontario: 2002–2013 [47] and Saskatchewan: 2005–2013 [48]) and one study in Germany (2006–2007 to 2009–2010 [44]). Four studies including one each from France [56] (2004–2010), Germany [52] (2011–2015: Using data from Neuropsychiatric Specialist Practices), the USA [46] (1970 versus 1980), and Canada [57] (Ontario: 2004/–005 to 2010–2011) reported stability in rates.

Two studies reported mixed results. One study, based in Rochester (USA), reported stability in incidence from 1975 to 1985 and a small but significant decrease from 1985 to 1994 [14]. The other study, based in Demark, reported significant increases in AD from 2000 to 2002–2003 followed by stagnation until 2009 [64].

Cohort studies

Of the 13 cohort studies only one [20] (Japan: 1988 versus 2002; dementia and AD, not VaD or other/unclassified dementia) reported an increase in incidence over time. In contrast, six studies reported significant decreases in dementia incidence including studies in the USA (Framingham, with the risk reduction observed only in persons with high education, 1977–2008 [36]; Indianapolis, African Americas, AD and dementia, 1992–2000 [28]; Washington Heights-Inwood Columbia Aging Project, total sample, Hispanic and African Americans, 1992–2013 [60]; and Bronx County [51], 1993–2015), France (1988–2010: Bordeaux, overall and women [29]), and the UK (2002–2013: mulit-site

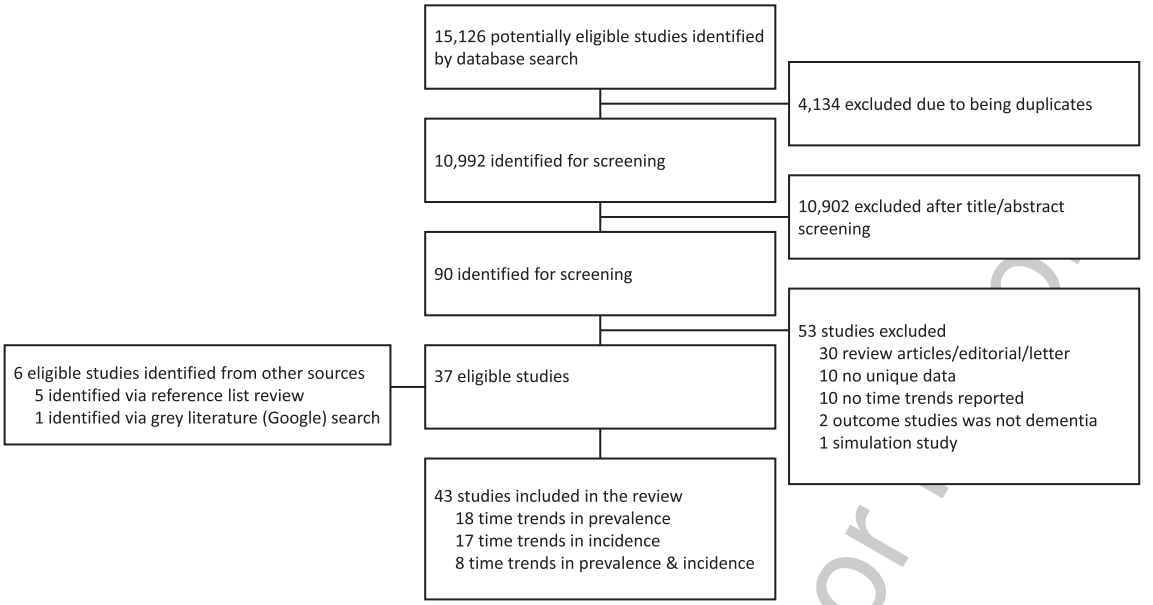

Fig. 1. Article selection.

[43]). The remaining seven studies reported stability in trends including studies based in: Sweden (1947–1957 versus 1957–1972: Lundby, senile and multi-infarct dementia [41] and 1971–1972 versus 2000–2001: Gothenburg [35]), China (1986–1989 versus 1997–1999: Beijing [30]), the Netherlands (1990–2005: Rotterdam [37]), Nigeria (1992–2001: Ibadan [28]), the USA (1997–2008: Chicago, only AD reported [27]), and UK (1989–2011: multi-site, significant decline in men only [33]).

DISCUSSION

This systematic review, the first to our knowledge to incorporate both historical and current secular trends in dementia prevalence and incidence, builds on previous (non-systematic [3, 4]) reviews, to reveal mixed findings, including stability, increases, and decreases in dementia rates worldwide over time across the last seven decades. The lack of a consistent findings, including between- and within-country variability, raises questions regarding comparability and quality of studies, and whether there is enough evidence to suggest that worldwide estimates of an increase in dementia currently reported are incorrect and need adjustment.

Prevalence

Differences in the pattern of secular trends in prevalence across different data resources and world regions were observed. Most record based studies report significant increases in prevalence over time from 1980 to 2013 including studies undertaken in the USA [9, 23], Canada [40, 57, 58], and France [56]. What is driving these increases is unclear. The results may reflect true increases in prevalence or, may reflect changes in perceptions of disease and increasing trends in diagnosis, changes in legal cut-points for treatment/insurance, and increases in knowledge and expertise around dementia in the last three decades. In contrast to findings of increasing prevalence, only one record-based study [21] (USA) reported a significant decrease (total sample and males). The contradictory results from the USA are surprising as both studies used the same data resource and their observation period overlapped. However, their definition of dementia varied; with significant decline observed when dementia was more narrowly defined and the assessment period shorter (1994–1999 versus 1984–2001). Lastly, only one study reported stability (Germany from 2007 to 2009); although a significant decline in prevalence was reported in women [54].

In contrast to the results from record-based studies, cohort studies generally reported stable prevalence rates of dementia (and AD) including studies from

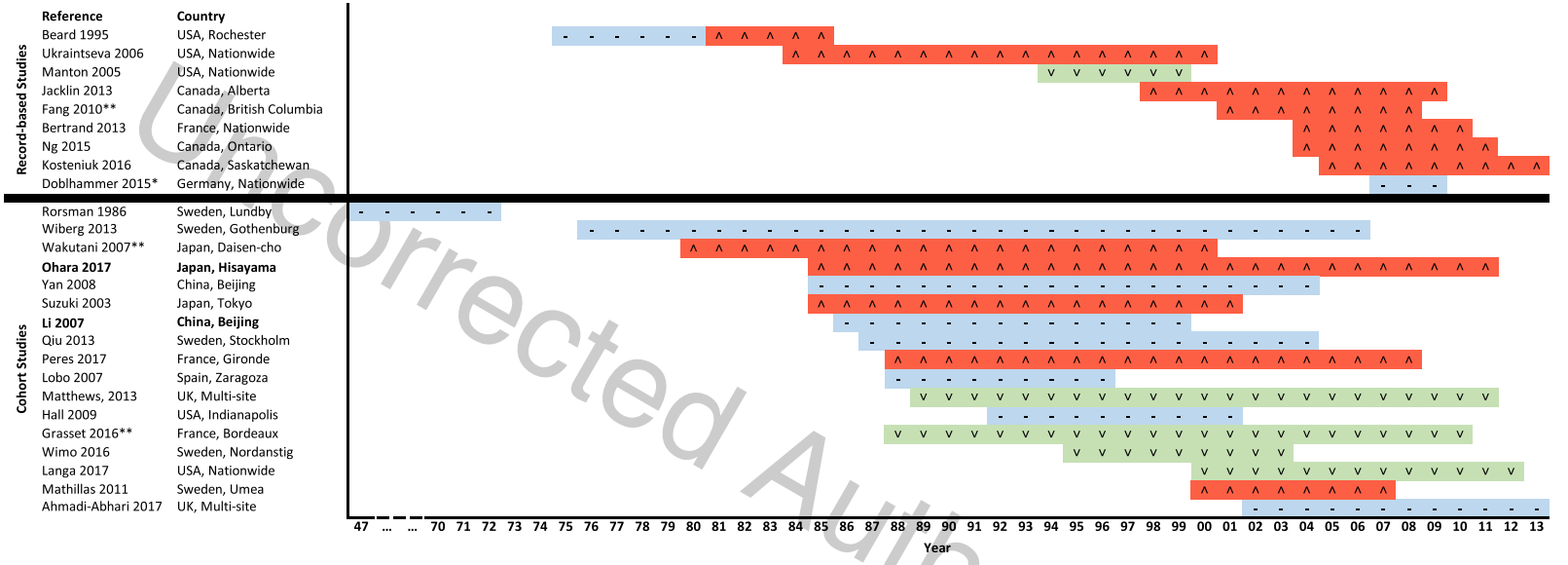

Fig. 2. Prevalence trends (based on statistical significance testing, unless otherwise stated) across studies stratified by study design and ordered by earliest baseline. *Significant decline only observed for women (little change over time in the total sample as shown in the figure), stable trend for men. **No statistical test of time trend completed. Bold: Indicates a lack of consistency in diagnostic criteria for dementia across time. Color Key: Blue, Stable rate over time; Green, Decrease in rate over time; Red, Increase in rate over time.

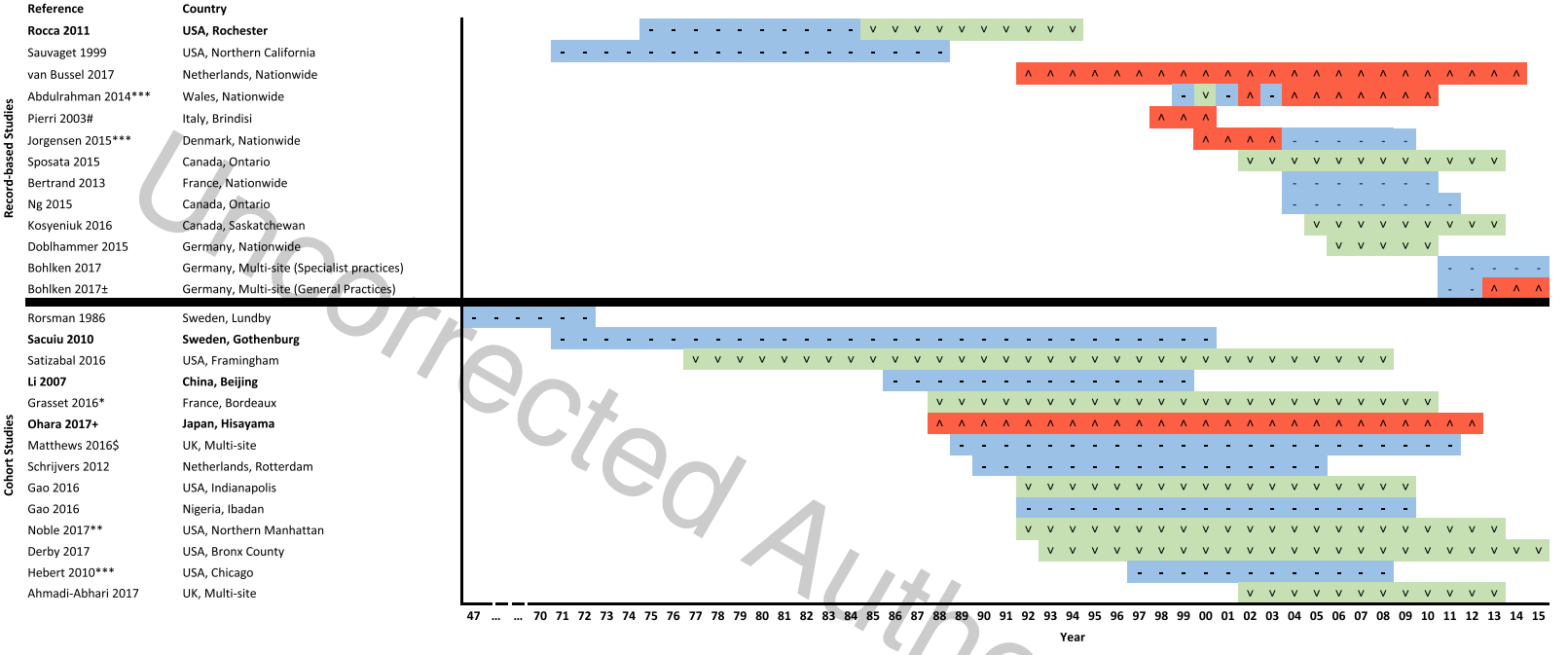

Fig. 3. Incidence trends (based on statistical significance testing, unless otherwise stated) across studies stratified by study design and ordered by earliest baseline. *Total sample and women only (Algorithmic NOT clinical diagnosis). **Total sample and when stratified by ethnicity (greatest decrease in Non-Hispanic Whites or African Americans; lowest in Hispanics). ***Only data for Alzheimer's disease (AD) is reported. $^{+}$Significant increase in all-cause dementia and AD. $^{\#}$No statistical test of time trend completed. $^{\$}$Significant reduction in men only. $^{\pm}$Increase mainly due to vascular dementia (VaD) and non-specific dementia (AD stable). Bold: Indicates a lack of consistency in diagnostic criteria across time. Key: Blue, Stable rate over time; Green, Decrease in rate over time; Red, Increase in rate over time.

Sweden, Spain, China (Beijing), and the USA. Decreasing prevalence rates have, however, been reported in studies from the USA, UK, and Sweden. The trends in decreasing prevalence in high-income Western countries generally appear in the most recent decades, suggesting occurrence possibly because of improved health and risk factor management, lifestyle changes, better education, and improved social welfare all of which could be implicit in changing dementia trends.

Significant increases in prevalence rates in cohort studies were, however, observed in France [53], Japan [20, 25, 61] (in rates of all-cause dementia and AD with VaD generally showing a J-shaped trend), and one study from Sweden [32]. In France, the sample were rural (farmers) and while rates increased sharply over the 20 years follow-up in the later born cohort, dementia tended to be milder and participants showed less deterioration and lower mortality over time [53]. This suggests that possibly in the later born cohort diagnosis was being made at a milder stage. In Japan, increases in prevalence of dementia (and AD) have been postulated to be linked to increases in the prevalence of metabolic risk factors, reduced mortality (e.g., from cardiovascular disease and stroke) and therapeutic advances in managing aging-related diseases. Regarding VaD, a decline in dementia prevalence from 1985 to 1998 was suggested to be linked to improvement in the management of hypertension, whereas the steep increase in metabolic disorders and partly insufficient control of hypertension were linked to increased dementia prevalence in 2005 [25]. The results from Japan are in line with other high-income Asian countries. A recent meta-analysis of prevalence studies by birth cohort in mainland China, Hong Kong, and Taiwan (1980 to 2012) showed that the unadjusted prevalence of dementia in these three regions increased monotonically (2.1% to 5.7%) from the earliest to the latest study periods [65]. The meta-analysis also reported a pattern of increasing prevalence, from less recent to most recent birth cohorts (see also [66]). A systematic review and meta-analysis of different prevalence studies from across Korea, found that in the past two decades, the prevalence of dementia (including trends for all dementia, AD, and VaD; pooled across 11 prevalence studies) has decreased until 2000–2005 and then increased thereafter (up to 2013) [67]. However, the trend was not statistically significant. When looking at the five [32, 34, 38, 39, 41] prevalence studies in Sweden, only one [32] reported an increasing trend over time (2000 to 2007). In contrast to the other Swedish studies, the sample was restricted to the very old, defined as people aged $\geq$70 years. Further, the method of dementia diagnosis included direct assessment in addition to medical record review (e.g., records from General Practitioners, hospitals, and institutions) and this could partly explain the increasing trend observed.

Incidence

Just under half (i.e., 40%) of the included studies reported a decline in incidence rates over time including studies from the USA [14, 28, 36, 51, 60], Canada [47, 48], Germany [44], the UK [43], and France [29]. Declining incidence findings are observed against a background of a rapidly aging population, increasing longevity and increased survival with chronic disease (including dementia [20, 34]) all of which would be expected to lead to an increase in incidence of dementia across subsequent cohorts. Similar to the prevalence findings, declining incidence may be due to better cardiovascular disease control, increased educational attainment [14], compression of cognitive morbidity, and improved care and social welfare. However, as the pattern of disease related comorbidity changes in current generations, particularly increased prevalence of diabetes worldwide [68], the gains seen in current generations may not necessarily be replicated in future generations.

In contrast, five studies reported an increase in incidence including four record based studies from sites in Italy [42], the Netherlands [49], Wales [59], and Germany [52] and one cohort study based in Japan [20]. The remaining studies report stability in trends including studies from France (record based study) [56], Sweden (cohort studies) [35, 41], China (cohort study) [30], the Netherlands (cohort study) [37], Nigeria (cohort study) [28], Germany [52] (record based study and findings observed in neuropsychiatric specialist practices only), the UK (cohort study - total sample and women; significant decrease in men) [33], Denmark (record based study) [4], Canada (record based study) [57], and the USA (record based study as well as a cohort study focused only on AD) [27, 46].

However, it is important to note that for some incidence studies while trends were not significant relatively large changes in risk over time were observed (see Supplementary Table 1). For example, a study from the UK [33] reported a 20% non-significant decline in risk over 20 years from 1989–1994 to 2008–2011 and a study from the

Netherlands [37] reported a 25% lower risk in a later born (2000–2005) compared to the earlier born cohort (1990–1995) and again the result was not statistically significant. This is in contrast to studies with smaller changes in risk over time where results are significant (i.e., Canada, Ontario 7.4% significant decline from 2002 to 2013 [47]). While we have chosen to focus on statistical significance, these results highlight that it is also important to look at the actual rates and size of change. Further studies, with increased numbers and longer follow-up times to confirm results, particularly small but significant changes, are needed.

Strengths and limitations

Due to the broad topic under review, the search was purposefully kept general, without time restrictions, to minimize the chances of missing relevant studies. This may represent an important bias given that diagnostic criteria and the sensitivity of physicians, has improved in the last decade and a more precise definition of dementia is possible nowadays than in the past. However, this allowed the opportunity for historical as well as current secular trends to be explored. There was large heterogeneity across studies in how dementia was defined, and data collected. Therefore, it was not possible to synthesis the findings in a meta-analysis. Instead, the review gives a comprehensive overview of time trends in dementia across different world regions. Figures showing the pattern of time-trends (based on statistical significance) and the reported percentage change in rates over time (Supplementary Material 2) are provided to allow for cross-study comparison. Further, not all studies have tested changes in trends over time statistically. Lastly, four studies, including two incidence [14, 35] and two combined prevalence/incidence studies [20, 30], did not maintain consistency in diagnostic criteria across time which could have affected the observed rates. However, a sensitivity analysis removing these studies from the results does not change the conclusions of mixed secular trend findings in dementia prevalence and incidence rates.

We included both record-based and cohort studies in the review. Discrepancies in findings between the two study designs may be attributable to several methodological factors. Cohort studies largely ascertain dementia diagnoses based on consistent study protocols over time, including case finding, diagnostic work-up and adjudication of cases according to (in the majority of studies) constant dementia criteria. In contrast, changes in the criteria used to establish dementia, or changes in perceptions of disease among individuals or their treating physicians in record-based studies introduces instability of diagnostic sensitivity. Similarly, in many countries a dementia diagnosis is required to arrange additional healthcare, e.g., admission to a nursing home, which may give rise to conflicting incentives to properly diagnose an individual. Additionally, case ascertainment based on classification systems in record-based studies may erroneously classify individuals, in part attributable to proceedings such as the aforementioned. On the other hand, beyond their study protocols, many cohort studies make substantial efforts to keep their participants in the study in order to minimize loss to follow-up thus reducing potential bias due to attrition. Moreover, some cohort studies further improve coverage of interval cases by linking their study data with medical records from general practitioners, by assessing hospital discharge letters, and by using pharmacy data.

CONCLUSIONS

There is conflicting evidence on the secular changes in prevalence and incidence of dementia worldwide. Some studies have found an increase in prevalence and incidence while others have shown a decline or stability in trends. Results vary across the different data sources (i.e., record based versus cohort study), sample demographics (i.e., population age and gender), and even regionally (i.e., some studies from the same country have reported contradictory findings). There is a clear gap in data from low and middle-income countries. Knowing the number of people at risk of future dementia will be important for service commissioning, planning and distribution of health and welfare resources with the aim to decrease future case numbers and the global burden of disease associated with dementia.

ACKNOWLEDGMENTS

The authors would like to thank Kazutaka Yoshida and Long Xie for assisting with translation of the non-English articles.

The work was supported by the National Institutes of Health (NIHR) [NIHR Global Group: DePEC 16/137/62].

Authors' disclosures available online (https://www.j-alz.com/manuscript-disclosures/18-0375r1).

SUPPLEMENTARY MATERIAL

The supplementary material is available in the electronic version of this article: http://dx.doi.org/10.3233/JAD-180375.

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