Review Article

The Incidence, Prevalence, and Mortality of Stroke in France, Germany, Italy, Spain, the UK, and the US: A Literature Review

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Background. Although the burden of stroke in terms of mortality and disability has been well documented in previous years, data after 2000 are limited. Therefore, the aim of this paper was to identify the epidemiology of stroke in the US and EU5 nations from data published in 2000 and later. *Methods.* Data from literature databases and online sources were collated to identify information relating to the incidence, prevalence, and mortality of stroke from the year 2000 onwards. *Results and Conclusions.* Twenty-three data sources were identified. The incidence of and mortality due to stroke both increase with age and are greater in males compared to females. Stroke is a common problem and likely to worsen in the US and EU5 as their populations age. However, pre-2000 trends of decreasing stroke mortality over time have continued after 2000, reflecting a consistent improvement in the treatment and care of patients with stroke.

1. Introduction

Strokes, or cerebrovascular accidents as otherwise known, are a heterogeneous group of conditions that manifest as neurologic deficits occurring due to interruption of the cerebral blood flow [1]. The causes, outcomes, and treatment strategies differ according to the categories of stroke. It is widely recognised that strokes are a major cause of adult disability due to both the debilitating initial symptoms and in many cases the severe long-term impairment in activities such as walking and speech [2, 3]. In addition to physical disabilities, the detrimental effects also extend to significant emotional burden. Indeed, a large number of stroke survivors are reported to experience depression [4]. The burden of stroke is further compounded by substantial economic costs; in the US, the total cost of stroke for 2008 was estimated to exceed US$65 billion, while, across the EU countries, the total annual cost of stroke was estimated to be €27 billion [3].

Several large reviews published in recent years have documented the burden of stroke in terms of mortality and morbidity [5–7]. These reviews, however, examined the epidemiology of stroke from data collected before 2000. Indeed, the authors reported that the epidemiology of stroke, as with the epidemiology of other cardiovascular diseases, may be changing over time in the populations of developed countries. This trend for changing epidemiology may be a result of a number of factors, including an aging population [7] and advances in the prevention and treatment of stroke [8].

Given the observed changes in the epidemiology of stroke over time, it is important to obtain a good overview of the most recent data. To the authors' knowledge, there are no published reviews to date examining the epidemiology of stroke that collate data after 2000 for both the EU and US. The primary aim of this paper was therefore to identify the incidence, prevalence, and mortality attributable to stroke and TIA, based on data collected after 2000. The secondary

aim of this paper was to determine the trends in the epidemiology of stroke over time since 2000, as reported in the included studies.

2. Methods

2.1. Paper Questions. The paper objectives were translated into the following research questions. (1) What is the incidence, prevalence, and mortality of stroke (and its subtypes) and TIA, and how does it vary geographically in the EU and US? (2) How does incidence, prevalence, and mortality of stroke, its subtypes, and TIA vary with patient characteristics, specifically age and gender? (3) How has the incidence, prevalence, and mortality of stroke, subtypes of stroke, and TIA varied over time geographically?

2.2. Identifying Studies from Literature Databases. A focused search of the major literature databases MEDLINE Embase and PubMed was undertaken on the 12th February 2010, using a structured set of keywords and MeSH terms. The search strategies developed consisted of terms for stroke (including for ischaemic stroke, intracerebral haemorrhage, subarachnoid haemorrhage, and TIA) and for epidemiology (including for incidence, prevalence, and morality). No restrictions on study design were applied to the search strategy; however, the searches were restricted to articles published in and after 2000, in order to obtain only the most recent data. The databases searched were chosen for their wide coverage of relevant journals and particularly the coverage of European journals.

Only studies which met or potentially met the following predefined inclusion criteria were included; epidemiological studies and reports that provided data on the incidence, prevalence, or mortality of stroke (of any subtype) or TIA were included. Literature reviews of epidemiological data were also included if they contained this information. Studies were included only if they presented data for one or more of the countries of interest, namely, the US, UK, France, Germany, Italy, and Spain. In addition to the publication date restriction applied to the search strategy (2000 and later), studies were only included that reported data collected in or after the year 2000.

Citations identified from literature databases were initially screened based on the title and abstract provided, to exclude citations of studies that clearly did not report data of interest. Full texts were obtained for the citations that were included after this first screening stage, and these were screened again based on the contents of their full texts. Screening was conducted by one reviewer. Only studies clearly meeting the inclusion criteria (as stated above) were included at this stage.

2.3. Identifying Studies from Online Searching. In addition to database searches, extensive online searching was conducted to identify data published outside of indexed journals. Online sources searched included country specific websites and agencies, and government and nongovernment health and statistics organisations including, but not limited to the

Centers for Disease Control and Prevention (US), British Heart Foundation (BHF) (UK and Europe), the Information System of the Federal Health Monitoring (Germany), and Istituto Nazionale di Statistica (Italy). In line with the studies included from the literature databases, data were only included from the online sources on the incidence, prevalence, or mortality of stroke or the subtypes of stroke or TIA, which adhered to the criteria described for the literature databases sources.

2.4. Data Extraction and Analysis. Data for one study, reported in more than one publication or online source, were identified and linked to prevent double-counting of data. Information from each study was extracted by one reviewer and checked by a second independent reviewer, with any discrepancies resolved following discussion between the reviewers. Data regarding the incidence, prevalence, and mortality of stroke and details on the study design and setting were extracted. Only information relating to the countries of interest was included. Following extraction, the data were examined for key trends. No quantitative analyses were conducted to pool estimates; general trends were described if information was available from multiple sources.

3. Results

3.1. Trial Flow. Of the 5731 references retrieved by the literature database search, 34 citations were identified during initial screening of abstracts as containing data potentially relevant to the paper. Screening of the subsequently sourced full texts identified 11 published papers meeting the inclusion criteria; these 11 publications were therefore included in the current paper. The additional online searching yielded 12 datasets and publications meeting the inclusion criteria.

Of these 23 total data sources, two sources reported data on French populations, two sources reported data on German populations, four sources reported data on Italian populations, three sources reported data on Spanish populations, five sources reported data on UK populations, and five sources reported data on US populations. Further, one source reported data on several EU5 populations, and another reported data on several EU5 populations and the US population.

3.2. Morbidity

3.2.1. The Incidence and Prevalence of Stroke (Any Subtype). Eight studies from five European countries reported the incidence of stroke (any type), Table 1. Most of the studies reported data for specific regions, with only one study from the UK providing a nationwide sample [17]. No studies were identified that compared the incidence of stroke between different countries. Studies report data for different countries, recruit disparate stroke populations (all stroke versus first stroke only), and vary considerably in the study design and data collection methods. It is therefore not appropriate to compare estimates between studies. To this point, studies conducted in the same country, reporting data by different geographical regions, reported markedly varied incidence

TABLE 1: Studies reporting incidence of stroke (any type).

Country	Study	Time of data collection	Stroke type	Setting	Sample size	Crude incidence in cases per 100 000 per year (95% CI where reported)		
						Male	Female	Total
France	Béjot et al. 2009 [9]	2000–2006	First ever stroke only	Regional: all inhabitants of the Dijon region (all ages)	152 606 (69 872 men; 82 734 women)	115.7 (106.3–125.6)	111.7 (103.2–120.7)	113.5 (107.2–120.1)
Germany	FHMS 2008 [10]	2008	All stroke	National: data from German hospitals on residents of Germany (all ages)Strokes classed as ICD-10 I60–I64	NR	346	354	350
Italy	Corso et al. 2009 [11]	2004-2005	All stroke	Regional: all inhabitants of the Valley of Aosta region (all ages)	123 748 (60 827 men; 62 921 women)	224 (186–261)	223 (186–260)	223 (197–249)
Spain	Vega et al. 2009 [12]	2005	All stroke	Regional: inhabitants of the Castilla y Leon, Extremadura, and Coumunitat Valenciana regions (ages >14 years)	201 205	148 (124–172)	134 (112–157)	141 (125–158)
	Alvaro et al. 2009 [13]	1998–2003	All stroke	National: incidence of hospitalisation for stroke, from the Spanish Ministry of Health Minimum Basic Data Set Office (data for all ages)	NR	NR	NR	160
	Fernández De Bobadilla et al. 2008 [14]	2004	All stroke	Incidence of hospital admissions for stroke for five centres, in patients aged >30 years	NR	NR	NR	220
UK	Rothwell et al. 2005 [15]	2002–2005	First ever stroke only	Regional: inhabitants of the Oxfordshire region (all ages)	91 106 (46 970 men; 44 136 women)	151	171	161
	BHF 2009 [16], Hippisley-Cox et al. 2004 [17]	2003	All stroke	National: data from GP practices across the UK (all ages)	NR	116	135	NR
US	No studies identified							

BHF: British Heart Foundation, CI: confidence interval, FHMS: Federal Health Monitoring System, NR: not reported, UK: United Kingdom, US: United States. Sources: [9–17].

values; for example, estimates from Spain ranged from 141 cases per 100 000 persons per year to 220 cases per 100 000 persons per year [12–14].

Fewer studies (five) reported data on the prevalence of stroke, Table 2. Data were found for only three countries (Italy, the UK, and the US), with none comparing prevalence between different countries [16–20]. Comparison across countries should be performed with caution owing to the heterogeneity between studies. For example, the 0.15%

prevalence reported in the study from Italy (without stratification by gender) is markedly lower than the prevalence reported by the studies from the UK and the US (which range from 1.7% to 2.6% without stratification by gender).

3.2.2. Age and Gender Variations in the Incidence and Prevalence of Stroke (Any Subtype). Six of the eight studies presented in Table 1 compared the crude incidence of stroke between males and females [9–12, 15, 17]. The data from

TABLE 2: Studies reporting prevalence of stroke (any type).

Country	Study	Time of data collection	Setting	Sample size	Prevalence in percent (95% CI where reported)		
					Male	Female	Total
France			No studies identified				
Germany			No studies identified				
Italy	D'Allessandro et al. 2009 [18]	2004	Inhabitants of the Valley of Aosta region aged ≥15 years	6930 (3223 men; 3707 women)	1.33 (0.9–1.79)	1.59 (1.24–2.05)	1.47 (1.21–1.78)
Spain			No studies identified				
UK	BHF 2009 [16]	2006-2007	Data from registered GP patients in England, Scotland, and Wales	61 660 614	NR	NR	1.7
		2006	Data from the Joint Health Surveys Unit Health Survey for England (individuals aged 16 years and over)	NR	2	2	NR
		2003	Data from the Scottish Health Survey (individuals aged 16 years and over)	NR	2	2	NR
		2005-2006	Data from the Welsh Health Survey (individuals aged 16 years and over)	NR	3	2	NR
		2005-2006	Data from the Northern Ireland Health and Social Wellbeing Survey (individuals aged 16 years and over)	NR	2	1	NR
	BHF 2009 [16], Hippisley-Cox et al. 2004 [17]	2003	Data from GP practices across the UK (data from patients of all ages)	NR	0.7	0.7	NR
US	CDC 2007 [19]	2005	Behavioral Risk Factor Surveillance System telephone survey conducted across the US Participants asked "has a doctor or other health professional ever told you that you had a stroke?"	356 112 (136 201 men; 219 911 women)	2.7 (2.5–2.8)	2.5 (2.4–2.7)	2.6 (2.5–2.7)
	CDC 2008 [20]	2008	Behavioral Risk Factor Surveillance System telephone survey conducted across the US Participants asked "ever told you had a stroke?"	NR	NR	NR	2.6

BHF: British Heart Foundation, CDC: Centers for Disease Control, CI: confidence interval, NR: not reported, UK: United Kingdom, US: United States. Sources: [16–20].

France, Germany, Italy, and Spain appear to indicate that there is no significant difference between the genders in terms of the incidence of stroke. However, the data from the UK studies suggests that the incidence may be higher in females compared to males. Two of the studies that reported the crude incidence also calculated incidence age-adjusted to the standard world and European populations [9, 11]. These adjusted incidences were observed to be higher in males compared to females. The study by Corso et al. reported that the incidence of stroke in males age-adjusted to the New World Health Organization (WHO) World Standard population was 122 cases per 100 000 persons per year compared to 77 cases per 100 000 persons per year in females in the Valley of Aosta in Italy. The study by Bejot et al. reported that the incidence of stroke in males age-adjusted to the European population was 107.5 cases per 100 000 persons per year compared to 68.9 cases per 100 000 persons per year in females in Dijon in France.

Data showing the relationship between age and gender on the incidence of stroke were reported by five studies [9, 11, 12, 15, 17]. Four studies (described in three sources) also presented data on the relationship between age and gender

on the prevalence of stroke [16, 21, 22]. Both the incidence and prevalence of stroke increase with age in both genders, with the incidence in males being generally higher than in females in the same age group (Figures 1 and 2). This trend agrees with the age-adjusted data for stroke from France and Italy [9, 11].

3.2.3. The Incidence and Prevalence of the Different Subtypes of Stroke and TIA.

A comparison of incidence rates between different subtypes of stroke is possible, based on the data reported in five studies (Table 3). Across these studies, it is apparent that the incidence of ischaemic stroke is much higher compared to that of haemorrhagic stroke. Further, where the two subtypes of haemorrhagic stroke are compared, the incidence of intracerebral haemorrhage is higher than that of subarachnoid haemorrhage.

Two studies compared the incidence of TIA with the subtypes of stroke [10, 15]; both studies indicated that the incidence of TIA is lower than that of ischaemic stroke but greater than that of haemorrhagic stroke (Table 3). Additionally, the data suggest that these trends apply in both the male and female subpopulations and for age-stratified incidence rates [10, 15].

3.2.4. Age and Gender Variations in the Incidence and Prevalence of the Different Subtypes of Stroke and TIA.

The incidence of ischaemic stroke and TIA, in terms of both first-time events and all events (overall, and for both genders independently), generally remains low until the 45 years to 55 years age range is reached, after which the incidence increases dramatically. The incidence of intracerebral haemorrhage follows a similar trend (though with much lower incidence). Of note, however, is that unlike ischaemic stroke and TIA, the rate of increase in the incidence of intracerebral haemorrhage with increasing age begins to slow at around the age of 80 years and may even begin to decrease [10, 15].

The relationship between incidence and age is less clear for subarachnoid haemorrhage. Data from two studies, one in Germany and the other in the UK, demonstrates that the incidence of subarachnoid haemorrhage increases with age until approximately 50 years in both males and females [10, 15]. Above 50 years of age, the trend in the incidence of subarachnoid haemorrhage is unclear without any obvious pattern or relationship. It should also be noted that subarachnoid haemorrhage is the only stroke subtype where the incidence is much greater in females than in males of the same age, an observation consistent across all age groups.

3.3. Mortality

3.3.1. The Mortality Rate of Stroke (Any Subtype).

Both the BHF and Organisation for Economic Co-operation and Development (OECD) studies report that France has the lowest mortality rate in both males and females across the EU5 countries (approximately 24 deaths per 100 000 persons per year to 38 deaths per 100 000 persons per year). These mortality rates appear comparable with the rates observed in the US (Figure 3). Italy and the UK demonstrate the highest rates of stroke-attributable mortality (approximately 41 deaths per 100 000 persons per year to 68 deaths per 100 000 persons per year) [16, 25].

3.3.2. Age and Gender Variations in the Mortality due to Stroke (Any Subtype).

Across all countries, mortality rates are consistently lower in females compared to males (Figure 3). Further data on the effect of gender on stroke-attributable mortality were reported by a study conducted in a Scottish population [26]. This study found that women aged 55 years to 84 years had lower stroke mortality than men, with the women-versus-men risk ratios (RRs) varying with age (65 years to 74 years, RR = 0.79 (95% CI: 0.76 to 0.81); 75 years to 84 years, RR = 0.94 (95% CI: 0.92 to 0.95)). However, the risk of stroke-attributable death in women aged 85 years or older is 15% greater compared to men of the same age (RR = 1.15 (95% CI: 1.12 to 1.18)).

Mortality due to stroke is affected by age, with greater age associated with higher rates of mortality [16]. Few deaths were observed in the UK in 2007 in those under 35 years of age (186 deaths); from this age, the absolute number of deaths increased, from a gradual increase in age groups close to 35 years to a more rapid increase across the older age groups. The peak in absolute number of deaths was observed in those aged 75 years and over (43 649 deaths). Mortality statistics for the US demonstrated a similar trend [27], although the peak was reported in those individuals aged 85 years or older since this additional age group was included in this data set.

The German Federal Health Monitoring System (FHMS) collected data on the mortality of subtypes of stroke, demonstrating that, regardless of the subtype, the mortality rate increased with age [28]. The increase in mortality rate was greatest for cerebral infarction, while the increase was minimal for intracranial haemorrhage.

3.3.3. The Mortality Rates of the Different Subtypes of Stroke and TIA.

There is a lack of mortality data relating to the subtypes of stroke, with data identified for the UK and US only [16, 27]. Haemorrhagic stroke was reported to be associated with twice the mortality rate of ischaemic stroke in both males and females in the UK, despite the incidence of the latter being greater; mortality rate is 10 deaths per 100 000 population per year for haemorrhagic stroke and 5 deaths per 100 000 population per year for ischaemic stroke [16]. It is difficult to draw further comparison between mortality rates of stroke subtypes, owing to the majority of strokes being classified as "unspecified subtype."

Similarly, deaths attributable to stroke in the US are rarely reported by stroke subtype. The difficulty in comparing mortality across subtypes is illustrated by the rate of mortality of "stroke, not specified as haemorrhage or infarction" being 25.1 deaths per 100 000 persons per year, while the rate is 9.4 deaths per 100 000 persons per year for intracerebral and other intracranial haemorrhage and less than 3 deaths per 100 000 persons per year for subarachnoid haemorrhage and cerebral infarction [27].

Country	Source	Detail		<15	15-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-84	>84
										Age (years)/Incidence of stroke (per 100 000 persons per year)									
France	Dijon Stroke Registry [9]	First ever stroke, 2000-2006, Dijon	Males			4.8					56.6		124.6		322.3		566		1168.5
			Females			9.7					39.8		63.3		153.2		315.7		998.5
Germany	No studies identified																		
Italy	Cerebrovascular Aosta Registry [11]	First ever stroke, 2004-2005, Valley of Aosta	Males	6	9	11		55		74		239		632		1326		2611	
			Females		19	17		24		42		91		316		983		2350	
Spain	Spanish sentinel health network [12]	All strokes, 2005	Males				15					150		352		721			
			Females				9.6					42		270		572			
UK	Oxford vascular study [16, 15]	First ever stroke, 2004 England	Males			0			35		76		214		678		1085		2063
			Females			3			26		60		140		464		1109		1863
	National Stroke Audit [17, 16]	First ever stroke, 2003 Britain	Males			7					114			393			794		
			Females			6					69			275			879		
US	No studies identified																		

FIGURE 1: Studies reporting the relationship between the incidence of stroke and age. Incidence reported as cases per 100 000 per year. Darker shading indicates higher incidence. BHF: British Heart Foundation, UK: United Kingdom. Sources: [9; 11; 12; 15; 16; 17].

Country	Source	Detail		<15	15-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-84	>84
										Age (years)/ Prevalence of stroke (%)									
France	No studies identified																		
Germany	No studies identified																		
Italy	SPREAD [22]	2001 census data	Total				0.065				0.410		1.275		4.500		8.796		16.185
Spain	No studies identified																		
UK	BHF [16, 23]	2006, England	Males		0.0				0.5		1.2		3.0		7.1		13.1		
			Females		0.2		0.1		0.4		0.9		2.3		4.2		10.7		
US	Framingham Heart Study [21]	1998-2002	Males										2.47		8.14		18.92		≥29.70
			Females										2.49		6.25		14.62		>21.75
	NHANES ([21]	1999-2002	Males								1.2		3.1		6.7		12.1		
			Females								2.1		3.0		6.3		11.5		

FIGURE 2: Studies reporting the relationship between the prevalence of stroke and age. Prevalence reported as percentage. Darker shading indicates higher prevalence. BHF: British Heart Foundation, NHANES: National Health and Nutrition Examination Survey, NHLBI: National Heart, Lung, and Blood Institute, SPREAD: Stroke Prevention and Educational Awareness Diffusion, UK: United Kingdom, US: United States. Sources: [16; 21; 22; 23].
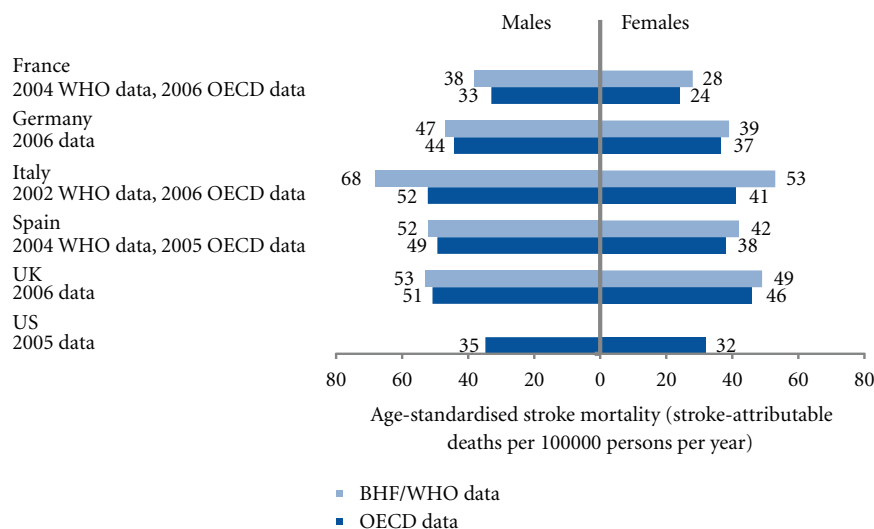

FIGURE 3: Age-standardised mortality attributable to stroke. BHF: British Heart Foundation, OECD: Organisation for Economic Co-operation and Development, UK: United Kingdom, US: United States, WHO: World Health Organization. Sources: [16, 25].

TABLE 3: Studies reporting incidence of stroke subtypes and transient ischaemic attack.

Country	Study	Time of data collection	Stroke type (first stroke/any stroke)	Setting	Sample size	Gender	Crude incidence in cases per 100 000 per year (95% CI where reported)				
							Ischaemic stroke	Haemorrhagic stroke			Transient ischaemic attack
								Intracerebral	Subarachnoid		
France	Béjot et al. 2009 [9]	2000–2006	First ever stroke only	All inhabitants of the Dijon region (all ages)	69 872	Male	100.0	13.7 (10.6–17.4)	1.6 (0.7–3.2)		NR
					82 734	Female	96.2	11.5 (8.9–14.6)	3.1 (1.9–5.0)		NR
					152 606	Total	97.9	12.5 (10.5–14.8)	2.4 (1.6–3.6)		NR
Germany	FHMS 2008 [10]	2008	All strokes	Data collected from German hospitals on residents of Germany (all ages)	NR	Male	263	44	11		120
						Female	271	39	16		139
						Total	267	41	14		130
Italy	Corso et al. 2009 [11]	2004-2005	All strokes	All inhabitants of the Valley of Aosta region (all ages)	60 827	Male	177 (144–211)	25 (13–38)	6 (1–13)		NR
					62 921	Female	174 (140–205)	22 (10–32)	7 (1–13)		NR
					123 748	Total	175 (152–199)	23 (15–32)	7 (2–11)		NR

Table 3: Continued.

Country	Study	Time of data collection	Stroke type (first stroke/any stroke)	Setting	Sample size	Gender	Crude incidence in cases per 100 000 per year (95% CI where reported)				
							Ischaemic stroke	Haemorrhagic stroke		Transient ischaemic attack
								Intracerebral	Subarachnoid	
Italy	Cesaroni et al. 2009 [24]	2001–2004	First ever stroke only	Inhabitants of Rome aged 35 years to 84 years	NR	Male	104	34		NR
						Female	81	28		NR
Spain	No studies identified									
UK	Rothwell et al. 2005 [15]	2002–2005	First ever stroke only	Inhabitants of the Oxfordshire region (all ages)	46 970	Male	136 (117–156)	13 (8–2)	3 (2–10)	45 (34–57)
					44 136	Female	147 (127–169)	12 (7–20)	12 (7–20)	89 (74–107)
					91 106	Total	141 (127–156)	12 (9–17)	7 (4–11)	66 (57–77)
US	No studies identified									

CI: confidence interval, FHMS: Federal Health Monitoring System, NR: not reported, UK: United Kingdom. Sources: [9–11, 15, 24].

3.4. Trends in Incidence, Prevalence, and Mortality of Stroke Over Time. The trend in the incidence of stroke over time is unclear since only two studies were identified reporting this data, with neither study demonstrating a clear trend [26, 29]. In one of the studies, which examined data from the French Dijon Stroke Registry from 1985 to 2006, a very small, nonsignificant decrease in the incidence of stroke between the periods 2001–2006 and 1996–2000 in persons aged 65 years to 80 years was observed [29]. The second study identified reported the incidence of first stroke-related hospitalisations in each year between 2000 and 2005 in Scotland, based on data from the National Health Service [26]; in this study, a decrease in incidence was observed for both males and females over the age of 85 years, while no clear trends were reported for the other age groups. Given that only these two data sources were identified reporting incidence rates over time, no firm conclusions can be drawn. In addition, no studies were identified that examined the change in incidence over time for any of the subtypes of stroke and TIA.

The data identified in this paper have indicated that the prevalence of stroke may be decreasing over time. In England, the change in the prevalence of stroke between 2003 and 2006 has decreased from 2.7% to 2.4% in males and from 2.3% to 2.2% in females in individuals aged ≥16 years [23]. No other study was identified that examined the trend in prevalence over time for a single population. Further, no studies were identified that reported the trend in stroke prevalence stratified by subtype.

Mortality attributable to stroke has decreased over time. The German FHMS reported that mortality rates for "stroke not specified as haemorrhage or infarction" in Germany decreased from 52.4 deaths per 100 000 in 2000 to 32.3 deaths per 100 000 in 2008 in both males and females combined (a greater rate of decline was observed for female patients). This trend is supported by data collected by the BHF from France, Germany, Italy, and Spain that suggest age-standardised death rates from stroke have decreased from 2000 to 2006 [16] and further from US data for the same time period that indicates stroke mortality as defined via ICD-10 codes has decreased steadily [27, 30]. In addition, UK data demonstrates that this steady decline in mortality rates is observed for both subtypes (haemorrhagic and ischaemic stroke) [16]; however, this data should be interpreted with caution owing to the high proportion of stroke-attributable mortality where the subtype was not determined.

4. Discussion

The incidence of stroke is considerable across the US and EU5 countries, with ischaemic stroke and TIAs being the most common events and therefore presenting the largest public health burden. Based on the data collected in this paper, the incidence of stroke in the six countries of interest ranges between 114 cases per 100 000 persons per year in France for first ever stroke to 350 cases per 100 000 persons per year in Germany for all stroke, while prevalence estimates ranged from 1.5% in Italy and 3% in the UK and US. It is not appropriate to compare estimates between studies due to the differences in study design; however, difference in incidence between countries has been reported in previous reviews [5–7]. Real differences in the incidence of stroke between countries would be unsurprising given the varied culture and lifestyle between countries which in turn results in marked differences in exposure to risk factors for stroke that include smoking, alcoholism, and diet [31].

Perhaps unsurprisingly, given the knowledge that the risk factors associated with degradation in the functioning of blood vessels appear, or become exacerbated, with age, the data identified through this paper demonstrate that the incidence and prevalence of stroke in general increases with age. This is true for TIA, ischaemic stroke, and intracerebral haemorrhage and is also noted in the reviews of pre-2000 data and in cardiovascular diseases in general [6, 7, 21, 30]. It is of note, however, subarachnoid haemorrhagic stroke does not follow this pattern, showing no clear relationship between incidence and age. This may be due to the distinct aetiology of subarachnoid haemorrhages, for which a mechanism has yet to be definitively elucidated.

Gender differences in stroke incidence were also identified in the paper, with higher estimates of ischaemic and intracerebral stroke observed in males than females of the same age, based on age-adjusted data. This supports findings from the paper of data pre-2000 by Appelros and colleagues [5], indicating that a shift in incidence has not occurred in recent years. The incidence of subarachnoid haemorrhagic stroke is, again, an exception to the trend observed with other subtypes; incidence is considerably higher in women than in men of the same age.

Published reviews on the epidemiology of stroke have not found consistent trends in the incidence of stroke over time. Some reviews have indicated that incidence has decreased, some have indicated that incidence has increased, and others have shown long-term declines to have begun to reverse in recent years [5, 6]. Our paper was unable to prove or disprove these previous trends, owing to limited studies identified that considered this topic [26, 29]. While, data reported for the English population suggests that the prevalence of stroke had been increasing from 1994 to 2003, a decline in prevalence was observed between 2003 and 2006 in both males and females in nearly all age groups [23]. This may be attributed to recent adoption of modern preventative treatments such as antiaggregants, statins, and antihypertensives, which are prescribed to at risk patients to reduce the risk of cardiovascular and cerebrovascular disease [31, 32].

Mortality relating to stroke in any population is dependent upon three main factors: (i) the incidence of stroke in the population, (ii) the quality of medical care available to individuals who have suffered a stroke, and (iii) the prevalence of cardiovascular disease and comorbidities that can affect the likelihood of patients surviving stroke events. The quality of medical care available both influences the number of individuals experiencing a stroke and the proportion of those individuals who die as a result of the stroke experienced. Only one study compared mortality data from the US to the EU5 and showed that the overall mortality rates for stroke in the US were similar to those in the EU5, with the

stroke-attributable mortality rates for men and women similar to those of France and Germany, respectively [25]. Of the six countries of interest, the mortality data found in this paper indicate that France has the lowest mortality due to stroke.

Stroke-attributable mortality is clearly higher in males than in females in all six of the countries of interest. This suggests that women are more likely to survive a stroke when compared to men. The data also suggest that whilst the likelihood of surviving stroke decreases with age in both genders, the rate of decrease is greater in males compared to females [33]. The mortality attributed to stroke increases with increasing age, as the risk of a stroke event increases and the risk of death per event increases [16, 25].

Stroke mortality rates have been decreasing consistently over time, with recent reports indicating a 29.2% reduction in stroke mortality between 1999 and 2008 in the US [34]. Indeed, the data suggest that death by stroke has fallen from the third to the fourth leading cause of death in the US [35]. This paper supports this and data before 2000, which suggests that the decline in mortality rates is a continuation of a trend that has been observed over several decades [6]. Further, given the stable incidence and prevalence estimates of recent years, the decrease in stroke-attributable mortality is most likely due to increasing survival after stroke. Such increased survival may be linked to advancements in treatment and rehabilitation of stroke patients.

Whilst the paper has identified some important trends, there are several difficulties associated in papering the epidemiology of stroke. Statistics on stroke can often be difficult to obtain and collect in a standardised or comparable manner. For example, the BHF report that stroke incidence is usually recorded from patient admission to hospital, but, from this data, it is often not possible to determine whether this was the first stroke or a subsequent stroke. Such classification then makes it difficult if the stroke should be included in the incidence measures [23]. There is also considerable heterogeneity in the designs of the studies identified, with patient populations and methods of collecting morbidity data varying between studies and thus potentially introducing differences in the data reported and conclusions drawn. Both national and regional data are presented in this paper in order to provide a comprehensive picture of stroke morbidity, though it should be noted that studies which investigated stroke epidemiology at a regional level may not report data that are representative of the country as a whole. It should be noted that there is a lack of national data from some countries; for example, for France there is only regional data available, which makes comparisons between countries increasingly difficult.

5. Conclusion

While stroke and TIA remain as major clinical burdens across the US and EU5 countries, the mortality attributable to stroke continues to decrease over time. The fact that the trend in decreasing stroke mortality is still being seen in the data collected after 2000 is encouraging and indicates that the treatment and rehabilitation of stroke patients have improved consistently. Therefore, whilst no clear decreases in incidence or prevalence have been observed and an increase in burden due to the aging populations of the US and EU5 countries is expected, improvements in the treatment of patients who suffer a stroke may mean that any increase in the absolute numbers of people experiencing and dying from stroke will not be as great as it would otherwise be. This paper has also highlighted the need for additional data on the epidemiology of stroke, in particular longitudinal studies that cover the years after 2000.

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