Age- and sex-specific rates of leukoariosis in TIA and stroke patients

Population-based study

Michela Simoni, MD,

MRCP

Linxin Li, MSc

Nicola L.M. Paul,

MRCP

Basil E. Gruter, BMed

Ursula G. Schulz, PhD

Wilhelm Küker, FRCR

Peter M. Rothwell,

PhD, FMedSci

Correspondence & reprint requests to Dr. Rothwell: Peter.rothwell@clneuro.ox.ac.uk

ABSTRACT

Objective: To determine any sex differences in age-specific prevalence or severity of leukoariosis, a marker of white matter ischemia, in population-based and clinic cohorts of TIA/stroke and in a systematic review of the literature.

Methods: Age-specific sex differences were calculated for both CT and MRI in the Oxford Vascular Study (OXVASC) and in an MRI-based clinic cohort. We pooled odds ratios (ORs) for leukoariosis in women vs men from published studies by fixed-effect meta-analysis, stratified by patient characteristics (stroke vs nonstroke) and CT vs MRI.

Results: Among 10 stroke studies (all CT-based), leukoariosis was most frequent in women (OR = 1.42, 95% confidence interval [CI] 1.27–1.57, $p < 0.0001$), with little heterogeneity between studies ($p = 0.28$). However, no such excess was seen in 10 reports of nonstroke cohorts (0.91, 0.67–1.24, $p = 0.56$). Moreover, excess leukoariosis in women on CT-imaging in OXVASC (1.38, 1.15–1.67, $p = 0.001$) was explained by their older age (age-adjusted OR = 1.01, 0.82–1.25, $p = 0.90$). Leukoariosis was more severe in older (≥ 75) women (CT-1.50, 1.14–1.97, $p = 0.004$ in OXVASC; MRI-1.70, 1.17–2.48, $p = 0.006$ in OXVASC and clinic cohort). However, leukoariosis was independently associated with early mortality (hazard ratio = 1.46, 1.23–1.73, $p < 0.0001$), suggesting that comparisons in older age groups will be biased by prior premature death of men with leukoariosis. Sex differences in severity of leukoariosis were not addressed in previous studies.

Conclusions: Previously reported excess leukoariosis in women with TIA/stroke is likely to be confounded by age and apparently greater severity in older women is likely to be biased by premature death in men with leukoariosis. *Neurology*® 2012;79:1215–1222

GLOSSARY

CI = confidence interval; OR = odds ratio; OXVASC = Oxford Vascular Study.

Onset of coronary artery disease is delayed in women compared to men,^{1,2} and women have a lower prevalence of peripheral and carotid artery disease, particularly before 75 years of age.³ However, the overall age-specific incidence of stroke differs much less between the sexes,⁴ the lifetime risk of stroke is similar in men and women,^{5,6} and stroke in women appears to be more severe and to lead to more disability than in men.^{7,8} This greater relative susceptibility to stroke than to coronary artery disease and the increased severity of stroke in women are unexplained, but could be due to a greater susceptibility to microvascular cerebral ischemia. Women have been reported to have a higher prevalence and severity of leukoariosis than men in some studies^{9–12} and a higher progression rate of leukoariosis by longitudinal MRI studies,^{13,14} although not all studies have confirmed this difference.^{15–17} To clarify whether leukoariosis is more prevalent or more severe in women than in men, or if the previously observed differences might be due to confounding by age, or be secondary to competing risk of earlier vascular death in men, we did a systematic review of the literature on leukoariosis and its association to sex,

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Supplemental data at www.neurology.org

Supplemental Data

From the Nuffield Department of Clinical Neurosciences, John Radcliffe Hospital, University of Oxford, UK.

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and studied brain imaging in patients in a population-based study on stroke and TIA (Oxford Vascular Study [OXVASC]) and in an independent TIA-clinic cohort.

METHODS Systematic review. For our systematic review of the literature we searched 2 main medical search engines, Medline and Embase (Medline 1950 to present date, Embase 1980 to present date), up to January 4, 2011. We used the terms leukoaraiosis or white matter changes and matched with the terms old age/aged, hypertension/high blood pressure, high cholesterol/hypercholesterolemia, cigarette smoking, ischemic heart disease, alcohol intake/alcohol consumption, diabetes mellitus, stroke, gender/sex, atrial fibrillation, peripheral vascular disease, dementia, carotid artery stenosis/disease. For the purpose of this article, we only considered studies reporting the association between sex and leukoaraiosis. There was no restriction by language of publication.

We calculated pooled odds ratios (ORs) by fixed effect meta-analysis (if heterogeneity between studies was $p > 0.1$ and otherwise by random effects, and p values with the χ^2 test) for presence of leukoaraiosis in women vs men for the studies reporting these data. We grouped the studies according to imaging used (CT or MRI), the mean age of their population, and the study setting (stroke patients vs nonstroke patients).

Population-based study. The OXVASC study is a population-based study of all acute vascular events in a population of 91,000 individuals registered with 63 primary care physicians in 9 general practices in and around Oxford, UK. Methods of OXVASC have been reported previously.¹⁴ In brief, multiple overlapping methods of “hot” pursuit were used to achieve near-complete ascertainment of all individuals with TIA or stroke. These included an urgent neurovascular clinic to which participating general practitioners and the local accident and emergency department send all individuals with suspected TIA or stroke whom they would not normally admit to hospital; daily assessment of admissions to the medical, stroke, neurology, and other relevant hospital wards; and daily searches of the local accident and emergency department attendance register. To not miss patients who presented late, were referred to other services, or were not referred to secondary care, we also performed monthly computerized searches of family doctor diagnostic coding, hospital discharge codes, and all cranial and carotid imaging studies performed in local hospitals. Patients are followed up for 10 years after the entry event. Follow-up visits include blood pressure check and a questionnaire on general health, recurrent events, medication, and neuropsychological tests at 1 and 6 months and 1, 5, and 10 years. Follow-up is complete for all patients for mortality via centralized death certification records and 5-year follow-up is available in over 95% of patients either by face-to-face follow-up or follow-up via their family doctor.

Consecutive patients with TIA or stroke (ischemic or hemorrhagic) assessed for OXVASC between April 1, 2002, and April 30, 2010, were included. The only exclusion criterion was lack of availability of adequate brain imaging. Leukoaraiosis was prospectively and independently coded by a neuroradiologist and by an experienced neurologist. Assessments were made blind to clinical data. Large cortico-subcortical strokes, definite subcortical lacunar lesions (well-delineated, oval or rounded, measuring 1.5 cm or less, or with the same signal intensity than CSF), and obvious tumors or cysts were excluded from the evaluation. However, less clearcut lacunar infarctions or demyelinating le-

sions in the context of more diffuse leukoaraiosis could not be reliably excluded by means of our visual assessment.

Leukoaraiosis was graded according to the following:

1. The ARWMC scale¹⁸ for both CT and MRI, rating 5 different regions in both hemispheres according to a 0–3 score. We used the total score derived from this scale and categorized it into absent (0), mild (1 to 5), moderate (6 to 10), and severe (over 10) leukoaraiosis.
2. A qualitative scale (“Oxford scale”) based on the severity score (absent, mild, moderate, or severe) of the Blennow scale¹⁹ for CT scans, and a modified version of the Fazekas scale,²⁰ considering periventricular and deep white matter lesions altogether, for MRI scans.

The neuroradiologist only applied the Oxford scale, while the neurologist applied both the ARWMC scale and the Oxford scale.

MRI scans were performed on a 1.5-T Philips Achieva scanner, and CT scans on a Toshiba, Aquilion 64, 64-slice scanner. The MRI sequences chosen for evaluation were the transverse T2 and the coronal fluid-attenuated inversion recovery. This latter was only available in coronal view, according to the clinical protocol applied in our hospital, and therefore it was mainly used to support and clarify the T2 findings.

Clinic cohort. We also studied MRI scans from a population of 766 consecutive ischemic strokes or TIA seen in a TIA/Stroke clinic in the Stoke-Mandeville Hospital, near Oxford, from patients who underwent MRI scan (1.5-T Siemens Symphony system) as part of their routine clinical investigation. These scans had been rated by means of the ARWMC scale by an experienced observer. Combination with the 496 scans rated with the same scale from OXVASC gave a total number of 1,262 MRI scans, and the same analyses on the association of leukoaraiosis to sex were repeated.

Reliability studies. Within the OXVASC cohort, the inter-rater agreement on presence and severity of leukoaraiosis on CT was assessed by κ statistics in a subset of 996 consecutive cases and for MRI on 100 cases. We also performed an agreement study between CT and MRI in the 416 patients who had had both modalities of imaging, using the SAS software to calculate both simple and weighted κ .²¹

The inter-rater reproducibility between the Stoke-Mandeville and the OXVASC raters was calculated on a sample of 130 consecutive scans.

Statistical analyses. We calculated age- and sex-specific rates of leukoaraiosis, stratified by severity. We also determined sex differences in presence of leukoaraiosis in 3 different age strata (<55, 55–74, ≥ 75) after further adjustment for age as a continuous variable in logistic regression analyses for any degree vs no leukoaraiosis; moderate-severe vs none-mild leukoaraiosis; and severe vs no, mild, and moderate leukoaraiosis. Multivariate logistic regression analyses were performed with presence of leukoaraiosis as outcome variable and female sex as a covariate, along with age and, in a second model, age and multiple vascular risk factors (hypertension, previous CVA, ischemic heart disease, diabetes mellitus, atrial fibrillation, peripheral vascular disease, current smoking, hyperlipidemia, carotid stenosis >50% on either side).

We determined the association between CT-detected leukoaraiosis and risk of death in all OXVASC patients and in those aged <75 years in a Cox regression analysis.

All analyses were performed using SPSS version 15.

Figure 1 Meta-analysis of studies identified by a systematic review of the published literature on the prevalence of leukoaraiosis stratified by sex

Pooled odds ratios for difference in prevalence of leukoaraiosis between sexes are shown. The studies have been stratified according to patient setting (stroke vs nonstroke patients), and according to the type of imaging used (CT or MRI). See supplemental data at www.neurology.org for e-references. CI = confidence interval; OR = odds ratio.

Standard protocol approvals, registrations, and patient consents. The OXVASC study was approved by the local research ethic committee, and all the patients signed an informed consent at entry in the study. Approval was obtained from the local research ethics committee for the TIA-clinic cohort.

RESULTS Our systematic review identified 33 potentially eligible studies, but only 19 (14 based on CT and 5 on MRI) reported data on presence of leukoaraiosis stratified by sex. Meta-analysis of data from these 19 studies showed excess leukoaraiosis in women (OR 1.19, 95% confidence interval [CI] 1.08–1.33, $p = 0.03$), but there was significant ($p < 0.0001$) heterogeneity between studies. When stratified by type of study population (figure 1), the excess leukoaraiosis in women was only seen in TIA and stroke cohorts (1.42, 1.28–1.57, $p < 0.0001$), with no sex difference in the nonstroke studies (0.91, 0.67–1.24, $p = 0.56$), which included healthy subjects, community-dwelling people, patients from

neurology or general medicine clinics, from dementia clinics, and from geriatric or neurology hospital wards. Although the nonstroke studies were generally small, these 2 estimates were significantly different ($p = 0.006$). Indeed, the frequency of leukoaraiosis was lower in women vs men in those nonstroke studies that used MRI (0.70, 0.56–0.86, $p = 0.001$). All studies in TIA/stroke populations were CT-based.

The OXVASC patients comprised 2,124 subjects (1,127 female) with age ranging from 21.9 to 99.6 years (mean = 73.8; SD = 13.4). Women were significantly older than men (75.7 vs 71.5, $p < 0.001$). Patients had been recruited following ischemic stroke (1,069), cerebral or ocular TIA (791), intracerebral hemorrhage (109), subarachnoid hemorrhage (67), and uncertain stroke or retinal artery occlusion (88). Brain imaging was available for review in 1,890 (89.0%) of 2,124 patients. The most common rea-

Table 1 Agreement study between CT and MRI evaluated by the same observer, on a total of 416 OXVASC patients investigated with both modalities^a

Age, y	κ	95% CI	p	κ for severity (0–3 scale)				
				Simple κ	95% CI	Weighted κ	95% CI	p
<65	0.65	0.53–0.77	<0.0001	0.57	0.45–0.69	0.69	0.59–0.79	0.01
>65	0.63	0.53–0.73	<0.0001	0.61	0.53–0.68	0.72	0.66–0.78	<0.0001

Abbreviations: CI = confidence interval; OXVASC = Oxford Vascular Study.

^a The κ results are given according to patients' age groups.

sons for nonimaging were death prior to or shortly after arrival at hospital, events occurring abroad, and ocular ischemia only. Of the 1,890 patients studied, 988 (52.3%) were women and the sex difference in age remained (75.3 vs 71.3, $p < 0.001$).

We reviewed 2,306 scans from the 1,890 patients (1,777 CT and 529 MRI, with 416 patients having both; table e-1 on the *Neurology*[®] Web site at www.neurology.org). The inter-rater agreement on presence of leukoaraiosis in 996 consecutive cases imaged by CT and rated by the Oxford scale was

moderate to good ($\kappa = 0.64$, 0.59–0.69, for presence of any leukoaraiosis, and 0.58, 0.55–0.62 for severity). The inter-rater agreement on presence of leukoaraiosis in 100 consecutive cases imaged by MRI and rated by the Oxford scale was also good ($\kappa = 0.78$, 0.65–0.90 for presence and 0.66, 0.56–0.76 for severity of leukoaraiosis). In the 416 patients who had both CT and MRI, agreement between independent assessments made on the different modalities was not significantly less than the interobserver reproducibilities of either modality alone (table 1).

Table 2 Differences between sexes in baseline clinical characteristics in the OXVASC study and in the Stoke-Mandeville cohort^a

	OXVASC cohort						Stoke-Mandeville cohort		
	CT			MRI			MRI		
	F (942)	M (835)	p ^b	F (240)	M (289)	p ^b	F (351)	M (415)	p ^b
Mean age	78.2; 11.6	74.2; 11.6	<0.01 ^c	66.5; 15.0	65.2; 13.2	0.31	71.6; 12.3	69.5; 11.8	0.02 ^c
	p ^d			p ^d			p ^d		
Hypertension	557 (59.3)	445 (53.4)	0.01 ^c	116 (48.3)	145 (49.8)	0.79	200 (57.3)	247 (60.4)	0.42
Previous CVA	121 (12.8)	101 (12.1)	0.67	18 (7.5)	17 (5.8)	0.49	35 (10)	46 (11.2)	0.64
Ischemic heart disease	151 (16.3)	194 (23.5)	<0.01 ^c	25 (10.5)	51 (17.6)	0.03 ^c	47 (13.6)	87 (21.4)	<0.01 ^c
Diabetes mellitus	115 (12.2)	114 (13.7)	0.40	28 (11.7)	43 (14.8)	0.31	44 (12.5)	68 (16.4)	0.15
Atrial fibrillation	159 (16.9)	177 (21.2)	0.02 ^c	17 (7.1)	28 (9.6)	0.35	35 (10.1)	38 (9.3)	0.71
Peripheral vascular disease	46 (4.9)	78 (9.4)	<0.01 ^c	10 (4.2)	20 (6.9)	0.19	8 (2.3)	24 (6.0)	0.02 ^c
Current smoking	119 (12.9)	127 (15.5)	0.13	39 (16.5)	55 (19)	0.49	49 (14.1)	98 (23.9)	<0.01 ^c
Hyperlipidemia	243 (26.7)	226 (27.7)	0.67	70 (30.6)	85 (29.6)	0.85	108 (39.3)	132 (38.3)	0.80
>50% Carotid stenosis	77 (13.1)	104 (17.7)	0.04 ^c	14 (7.9)	24 (10.5)	0.40	25 (11.7)	43 (16.2)	0.19
Leukoaraiosis									
Presence	527 (55.9)	400 (47.9)	<0.01 ^c	135 (56.3)	163 (56.4)	1.00	223 (63.5)	236 (56.9)	0.07
OR (95% CI)	1.38 (1.15–1.67)		<0.01 ^c	0.99 (0.70–1.40)		0.97	1.32 (0.99–1.77)		0.06
Age-adjusted OR (95% CI)	1.01 (0.82–1.25)		0.90	0.89 (0.60–1.32)		0.56	1.15 (0.83–1.60)		0.39
Fully adjusted OR (95% CI)	0.84 (0.65–1.09)		0.18	0.74 (0.46–1.19)		0.22	1.14 (0.68–1.91)		0.62

Abbreviations: CI = confidence interval; OR = odds ratio; OXVASC = Oxford Vascular Study.

^a Mean age is reported in years; SD, while all the other variables are reported as number of patients with the condition (% of total). Fully adjusted means adjusted for age and for all the other vascular risk factors listed in the table.

^b t Test.

^c Significant.

^d χ^2 .

Figure 2 Age- and sex-specific distribution of leukoaraiosis on CT and MRI scans

Distribution of leukoaraiosis on CT scans of Oxford Vascular Study (OXVASC) patients (A) and MRI scans of OXVASC (B) and Stoke-Mandeville (C) patients, according to sex and age. The severity of leukoaraiosis is rated according to the ARWMC scale. Numbers of patients in each category are reported below the columns, and mean age for men and women in each age category is reported.

For more detail on the intra and inter-rater reliability studies, see table e-2.

Leukoaraiosis appeared to be more frequent in women than in men in those patients imaged by CT in OXVASC (1.38, 1.15–1.67, $p = 0.001$), but women imaged with CT were older than men imaged with CT and when we adjusted the association for age there was no longer any excess leukoaraiosis in women (adjusted OR = 1.01, 0.82–1.25, $p = 0.90$) (table 2 and table e-1). Moreover, in OXVASC patients imaged by MRI, in whom the males and females were of similar age, there was no sex difference in the frequency of leukoaraiosis (table 2 and table e-1). On both CT and MRI, age was the most powerful predictor of presence of leukoaraiosis (OR per 10 years = 2.16, 1.96–2.59, $p < 0.001$ for CT; 2.59, 1.96–2.83, $p < 0.001$ for MRI).

We also stratified analyses by age in 10-year bands from age 55 (figure 2 shows grading according to the ARWMC scale; see figure e-1 for grading according to the Oxford scale). Leukoaraiosis was reported more frequently on MRI than on CT, particularly in the younger age groups, but there was little consistent sex difference in frequency with either modality. However, subcategorization by severity of leukoaraiosis (ARWMC scale) showed a trend toward more severe leukoaraiosis in women above 75 years of age, both on CT and MRI (figure 2, table 3) in OXVASC and on the merged MRI cohort from OXVASC and the clinic cohort from Stoke Mandeville (OR for severe leukoaraiosis in women vs men in the composite MRI cohort: 2.79, 1.63–4.79, $p < 0.0001$; figure 2, table 3).

To determine whether leukoaraiosis might be associated with an increased risk of premature death and hence a competing-risks bias due to earlier death in men compared with women, we determined the association between the presence of leukoaraiosis on CT at entry in OXVASC and time to death in a Cox regression analysis, also including age, sex, and hypertension as covariates. Leukoaraiosis was a significant independent predictor of death (hazard ratio 1.46, 95% CI 1.23–1.73, $p < 0.0001$). This association remained when analysis was confined to patients younger than 75 years (1.53, 1.08–2.18, $p = 0.02$).

DISCUSSION Clinical onset of coronary artery disease and peripheral vascular disease is delayed in women compared with men, but stroke incidence differs much less.¹ One possible explanation is that women are predisposed to cerebral ischemia, which might be reflected in a greater frequency of leukoaraiosis, as has been reported previously in some studies.^{9–12} However, not all studies have found this sex difference, and given an absence of published

Table 3 Odds ratios for prevalence of different degrees of leukoaraiosis in women vs men, according to age, in the OXVASC cohort and in the merged OXVASC and Stoke-Mandeville population^a

Age, y	Leukoaraiosis	Imaging	OXVASC patients			OXVASC and Stoke-Mandeville (MRI only)		
			OR	95% CI	p	OR	95% CI	p
<55	Any	CT	0.52	0.17-1.59	0.250	—	—	—
		MRI	0.83	0.33-2.12	0.700	1.04	0.53-2.06	0.904
	Moderate/severe	CT	1.72	0.10-29.5	0.710	—	—	—
		MRI	0.46	0.08-2.73	0.395	3.03	0.87-10.61	0.083
	Severe	CT	NA	NA	NA	—	—	—
		MRI	NA	NA	NA	0.58	0.05-6.68	0.666
55-74	Any	CT	0.97	0.68-1.39	0.880	—	—	—
		MRI	1.25	0.70-2.22	0.546	0.96	0.68-1.35	0.809
	Moderate/severe	CT	0.71	0.45-1.14	0.154	—	—	—
		MRI	0.52	0.26-1.03	0.060	0.86	0.58-1.28	0.460
	Severe	CT	1.12	0.55-2.30	0.755	—	—	—
		MRI	0.65	0.22-1.92	0.431	1.13	0.52-2.46	0.751
≥75	Any	CT	1.20	0.85-1.70	0.299	—	—	—
		MRI	1.03	0.46-2.34	0.941	1.44	0.90-2.29	0.130
	Moderate/severe	CT	1.28	0.97-1.69	0.087	—	—	—
		MRI	2.04 ^b	1.05-3.96 ^b	0.035 ^b	1.70 ^b	1.17-2.48 ^b	0.006 ^b
	Severe	CT	1.43	0.97-2.11	0.076	—	—	—
		MRI	2.06	0.97-4.40	0.062	2.79 ^b	1.63-4.79 ^b	<0.0001 ^b

Abbreviations: CI = confidence interval; OR = odds ratio; OXVASC = Oxford Vascular Study.

^a Leukoaraiosis was rated with the ARWMC scale both on CT and MRI. Odds ratios are also adjusted for age as continuous variable in order to minimize the effect due to age within single age stratum.

^b Significant.

data from MRI-based studies in patients with TIA or stroke, we determined sex differences in frequency and severity of leukoaraiosis using both CT and MRI in a population-based TIA/stroke incidence study, a clinic cohort, and a systematic review of the literature.

We found that the apparent excess of leukoaraiosis in women with TIA/stroke was confounded by age, with no sex difference on CT or MRI after adjusting or stratifying by age. We also found good inter- and intrarater reliability of assessment of leukoaraiosis by both imaging modalities.

We did find that leukoaraiosis was more severe in women than men at older ages. This finding was consistent on both CT and MRI and in the population-based cohort and clinic cohort. This sex difference could in theory reflect an increased susceptibility of white matter to ischemia in older women, but it is more likely to be an artifact due to sex differences in premature death, i.e., men who survive to their 80s and 90s are a more highly selected group than are women of the same age. In the OXVASC cohort of imaged patients reported here, for example, there were 242 women aged over 85 years, but only 112 men. In other words, about 130 more men than

women born in the same years had already died. Even if the presence or severity of leukoaraiosis were only weakly associated with premature death (e.g., a relative increase in mortality of 10%), it would be enough to account for the sex differences that we have observed in older age groups. In fact, the association that we observed between leukoaraiosis and risk of subsequent death in the OXVASC cohort was stronger. The association between leukoaraiosis and increased mortality has been reported in other studies, either in the general population^{22,23} or in stroke patients.^{24,25}

In patients under the age of 75 years, on the other hand, the numbers of men and women are almost identical (441 men vs 357 women), with much less potential for bias due to premature death, and we found no sex difference in leukoaraiosis. There was a trend for leukoaraiosis to be more severe in men than women under the age of 65, but the numbers were too small for us to be able to draw any conclusion.

Our study has some potential shortcomings. First, we used semiquantitative methods to assess leukoaraiosis severity and our observations were mainly based on CT scans. However, despite the fact that reproducibility of rating scales is influenced by the

nature of the scale itself and by the expertise of the raters,^{26,27} we found good intra- and inter-rater reproducibility for both our CT and MRI evaluations. Moreover, although CT scans have a lower sensitivity for detection of white matter lesions when compared with MRI, CT-detected white matter changes are clinically relevant,²⁸ and have good neuropathologic validity.^{29,30} The concordance of our results between the MRI cohorts in our study and between the MRI and CT is reassuring.

Second, not all white matter changes represent chronic ischemia. We might occasionally have included demyelinating or vasculitic lesions or previous focal ischemic lesions, as these are not always possible to distinguish from leukoaraiosis by means of visual evaluation. However, we believe that this would be unlikely to have resulted in any major bias. Third, in the systematic review, we were only able to identify CT-based studies in stroke populations, while the studies in other settings were based both on CT and on MRI. However, we also report the largest single-center stroke-based MRI cohort so far to address sex differences in leukoaraiosis.

Overall, therefore, we consider that our findings are unbiased and reliable. The association between presence of leukoaraiosis and female sex can be explained by the strong association of leukoaraiosis to age and by the over-representation of female sex in the older patients with TIA and stroke. The greater severity of leukoaraiosis in older women is most likely an artifact due to greater risk of premature death in men with leukoaraiosis. We have found no evidence to support the hypothesis that women have a greater susceptibility to white matter ischemia than men.

AUTHOR CONTRIBUTIONS

Michela Simoni, MD, MRCP: study concept and design, acquisition of data, draft and revision of the manuscript, statistical analysis, and interpretation of data. Linxin Li, MSc: revision of the manuscript content, acquisition of data. Nicola L.M. Paul, MRCP: revision of the manuscript content, acquisition of data. Basil E. Gruter, BMed: revision of the manuscript content, acquisition of data. Ursula G. Schulz, PhD: revision of the manuscript content, acquisition of data. Wilhelm Küker, FRCR: revision of the manuscript content, acquisition of data. Peter M. Rothwell, PhD, FMedSci: study concept and design, draft and revision of the manuscript, analysis and interpretation of data, study supervision.

DISCLOSURE

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Practicing Neurologists: Take Advantage of These CMS Incentive Programs

Medicare Electronic Health Records (EHR) Incentive Program

The Medicare EHR Incentive Program provides incentive payments to eligible professionals, eligible hospitals, and critical access hospitals as they adopt, implement, upgrade or demonstrate meaningful use of certified EHR technology. Through successful reporting over a five-year period, neurologists are eligible for up to \$44,000 through the Medicare incentive program. To earn the maximum incentive amount, eligible professionals must begin demonstrating meaningful use by October 3, 2012. Learn more at www.aan.com/gol/practice/pay/ehr.

Medicare Electronic Prescribing (eRx) Incentive Program

The Medicare eRx Incentive Program provides eligible professionals who are successful electronic prescribers a 1% incentive for meeting reporting requirements during the 2012 calendar year. To be eligible, physicians must have adopted a “qualified” eRx system in order to be able to report the eRx measure. This program has also begun assessing payment adjustments for eligible professionals who have not yet begun participation in the program. Learn more at www.aan.com/gol/practice/pay/eRx.

Physician Quality Reporting System (PQRS)

The Physician Quality Reporting System provides an incentive payment for eligible professionals who satisfactorily report data on quality measures for covered professional services furnished to Medicare beneficiaries. Eligible professionals who report successfully in the 2012 PQRS Incentive Program are eligible to receive a 0.5% bonus payment on their total estimated Medicare Part B Physician Fee Schedule allowed charges for covered professional services. Learn more at www.aan.com/gol/practice/pay/pqrs.