Ischemic Stroke Rate Increases in Young Adults: Evidence for a Generational Effect?

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Background—The incidence rates of ischemic stroke and ST-segment elevation myocardial infarction (STEMI) have decreased significantly in the United States since 1950. However, there is evidence of flattening of this trend or increasing rates for stroke in patients younger than 50 years. The objective of this study was to examine the changes in incidence rates of stroke and STEMI using an age-period-cohort model with statewide data from New Jersey.

Methods and Results—We obtained stroke and STEMI data for the years 1995–2014 from the Myocardial Infarction Data Acquisition System, a database of hospital discharges in New Jersey. Rates by age for the time periods 1994–1999, 2000–2004, 2005–2009, and 2010–2014 were obtained using census estimates as denominators for each age group and period. The rate of stroke more than doubled in patients aged 35 to 39 years from 1995–1999 to 2010–2014 (rate ratio [RR], 2.47; 95% CI, 2.07–2.96 [*P*<0.0001]). We also found increased rates of stroke in those aged 40 to 44, 45 to 49, and 50 to 54 years. Strokes rates in those older than 55 years decreased during these time periods. Those born from 1945–1954 had lower age-adjusted rates of stroke than those born both in the prior 20 years and in the following 20 years. STEMI rates, in contrast, decreased in all age groups and in each successive birth cohort.

Conclusions—There appears to be a significant birth cohort effect in the risk of stroke, where patients born from 1945–1954 have lower age-adjusted rates of stroke compared with those born in earlier and later years. (*J Am Heart Assoc.* 2016;5:e004245 doi: 10.1161/JAHA.116.004245)

Key Words: epidemiology • ischemic stroke • myocardial infarction

The rates of ischemic stroke and ST-segment elevation myocardial infarction (STEMI) have decreased substantially since 1950. The Centers for Disease Control and Prevention (CDC) estimates that from 1950 to 1999, deaths from myocardial infarction (MI) decreased by 56% and deaths from stroke by 70%.[1] Fang and colleagues[2] found nearly a 50% decrease in the incidence of stroke in the United States from 1988 to 2008. In the Atherosclerosis Risk in Communities (ARIC) study, the rate of MI decreased by 4.7% per year in patients without a history of MI.[3] The Kaiser Permanente Northern California Health Care System found a 24% decrease in MI incidence between 2000 and 2008.[4] Similar decreases in incidence were seen in many countries including a nearly 50% decline in MI in Denmark between 1984 and 2008,[5] a 74% decrease in MI in the Whitehall II study from the United Kingdom,[6] and a greater than 60% decrease in MI in Zagreb, Croatia, from 1979 to 2001.[7] In Canada, the rate of hospital admissions for stroke decreased by 27% between 1995 and 2004.[8] In a study from the Joinville community in Brazil, the rate of stroke declined by 27%.[9] The CDC has attributed the declines to primary preventive efforts including reductions in smoking, blood pressure, and blood cholesterol.

There have been, however, several reports that the decreasing trends in stroke and MI are now abating or potentially reversing. Lee et al[10] reported increases in MI during the early years of the 21st century in Taiwan. As early as the 1980s, there were reports of a slowing of the decline in stroke rates in the United States.[11] Kissela and colleagues[12] found a decreasing trend of ischemic stroke incidence in patients aged 55 years and older but an increasing trend in those younger than 55. Similar results were found in Dijon, France, in young men.[13] Recent studies have shown similar increases in stroke hospitalizations in young adults the United States and Denmark.[14,15]

Age-period-cohort (APC) analyses have been used to study changes in trends of these variables over time. The age component provides insight into the effect of physiological changes over time due to aging. The period component allows for an understanding of how secular changes over time affect outcomes. These could include improvements in healthcare over time that may have population-wide effects during the period under study. The birth cohort component provides information on the effect of early-life influences on outcomes. Individuals in a birth cohort share similar life course experiences, ie, period effects occur at the same age for individuals within the birth cohort.

The objective of this study was to use APC analyses to examine differences in the incidence rates of ischemic stroke and STEMI in New Jersey during the past 20 years. Using this methodology, we attempted to unravel the separate effects due to aging, secular changes, and life course experiences on these outcomes.

Materials and Methods

We obtained data from the Myocardial Infarction Data Acquisition System (MIDAS) for the years 1995–2014. MIDAS is an administrative database containing hospital records of all patients discharged from nonfederal hospitals in New Jersey with a diagnosis of cardiovascular disease or an invasive cardiovascular procedure.[16] Information from death certificates was linked to the hospitalization records. The data were obtained from the New Jersey Department of Health utilizing the New Jersey Discharge Data Collection System (NJDDCS) and the New Jersey state and Rutgers Robert Wood Johnson Medical School institutional review boards approved the study and waived all patient consent requirements.

We identified all hospitalizations for ischemic strokes utilizing *International Classification of Diseases, 9th Revision, Clinical Modification* (*ICD-9-CM*) primary discharge diagnostic codes of 433.NN–434.NN. STEMIs were identified by an *ICD-9-CM* code of 410.NN while excluding those with codes of 410.7N, indicating a non–STEMI, and 410.N2, indicating a prior MI. Primary discharge diagnosis codes were used to increase the specificity that the hospitalizations were for incident stroke or STEMI. Secondary diagnosis codes for strokes have been shown to overestimate stroke counts by including prior events.[17] The denominators for the incidence rates were determined for each sex, year of birth, and incident year utilizing New Jersey midyear census and intercensal estimates.[18]

Statistical Analysis

In our primary analysis, we calculated incidence rates for ten 5-year age groups: 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, 70 to 74, 75 to 79, and 80 to 84

years. We divided the data into four 5-year time periods: 1995–1999, 2000–2004, 2005–2009, and 2010–2014. We measured incidence rates as a function of age, period, and birth cohort and developed 4 models based on prior work using APC methods.[19–21] The models estimated incidence rates by Poisson regression using generalized estimating equations (GEE). The use of GEE corrects for possible overdispersion of the Poisson estimates.[22] The first model, the parsimonious model, used age as the sole covariate and took the form: $\gamma_i = \mu + \alpha_i + \varepsilon_i$ where μ is the mean count, α_i is the effect of the age group i, and ε_i the random error term. We then tested more complex nested models and compared model goodness-of-fit from the parsimonious model. The second model included the period as an integer value with values 1, 2, 3, or 4 and took the form $\gamma_{ij} = \mu + \alpha_i + \beta \times j + \varepsilon_{ij}$ where j is the time period. The third model included the period as a categorical value and took the form: $\gamma_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$ where β is the effect of period j. The fourth model added the interaction term for age and period and took the form: $\gamma_{ij} = \mu + \alpha_i + \beta_j + \alpha_i \times \beta_j + \varepsilon_{ij}$. Based on the relationship between the age×period interaction and the birth cohort, the interaction term closely approximates the effect of the birth cohort. We compared the quasi-Akaike Information Criterion (QIC) for each model to test goodness-of-fit for variable selection.[23]

In a second analysis, we utilized five 10-year birth cohorts, those born between 1925–1934, 1935–1944, 1945–1954, 1955–1964, and 1954–1974, and who were aged 45 to 65 years. These birth cohorts and age groups were chosen as they had significant overlap by age where data were available in our data set allowing for intercohort comparisons. We compared birth cohorts while adjusting for age using a model that included the birth cohort as a categorical variable and age as a continuous variable.

Results

APC Analysis of Ischemic Stroke and STEMI Incidence Rates

The rates of ischemic stroke and STEMI by time period and age groups are shown in Table 1. Overall, the rate of stroke for those aged 35 to 84 years decreased from 314.1 strokes per 100 000 person-years (PY) during 1995–1999 to 271.0 per 100 000 PY during 2010–2014. The decrease in STEMI was much larger, decreasing by more than 60% from 206.4 to 84.7 STEMIs per 100 000 PY from 1995–1999 to 2010–2014.

Using QIC, we found that the fourth model, which included the age×period interaction term, was a better fit than either the parsimonious model (age only) or the second model (age plus period). We used this model to determine changes in rates by time periods (see Table 2 for model comparisons).

Table 1. Incidence Counts and Rates of Ischemic Stroke and STEMI in New Jersey From 1995 to 2014 in Patients Aged 35 to 84 Years

Years	Age Range, y	Population, PY	Ischemic Stroke		STEMI	
			Count	Rate (Per 100K PY)	Count	Rate (Per 100K PY)
1995–1999	35–84	19 555 178	61 427	314.1	40 363	206.4
2000–2004	35–84	20 921 037	52 853	252.6	28 116	134.4
2005–2009	35–84	21 339 733	54 533	255.5	18 902	88.6
2010–2014	35–84	21 737 982	58 906	271.0	18 417	84.7
1995–1999	35–39	3 388 724	323	9.5	712	21.0
	40–44	3 114 870	713	22.9	1583	50.8
	45–49	2 693 594	1225	45.5	2753	102.2
	50–54	2 274 108	2342	103.0	3956	174.0
	55–59	1 796 488	3947	219.7	4237	235.8
	60–64	1 513 182	5643	372.9	4530	299.4
	65–69	1 510 118	8875	587.7	5422	359.0
	70–74	1 386 067	12 461	899.0	6095	439.7
	75–79	1 133 623	13 932	1229.0	6058	534.4
	80–84	744 404	11 966	1607.5	5017	674.0
2000–2004	35–39	3 241 914	341	10.5	541	16.7
	40–44	3 372 477	769	22.8	1206	35.8
	45–49	3 043 916	1355	44.5	2042	67.1
	50–54	2 671 313	2331	87.3	2859	107.0
	55–59	2 190 617	3714	169.5	3444	157.2
	60–64	1 676 581	4979	297.0	3203	191.0
	65–69	1 396 767	6866	491.6	3245	232.3
	70–74	1 321 957	9538	721.5	3635	275.0
	75–79	1 162 609	11 874	1021.3	4092	352.0
	80–84	842 886	11 086	1315.2	3849	456.6
2005–2009	35–39	2 835 235	489	17.2	415	14.6
	40–44	3 171 137	987	31.1	869	27.4
	45–49	3 274 902	1872	57.2	1573	48.0
	50–54	2 912 908	3044	104.5	2333	80.1
	55–59	2 490 683	4432	177.9	2616	105.0
	60–64	1 983 167	5807	292.8	2598	131.0
	65–69	1 502 349	7235	481.6	2192	145.9
	70–74	1 222 577	8378	685.3	2006	164.1
	75–79	1 085 507	10 800	994.9	2116	194.9
	80–84	861 268	11 489	1334.0	2184	253.6
2010–2014	35–39	2 500 010	589	23.6	339	13.6
	40–44	2 832 408	1303	46.0	826	29.2
	45–49	3 110 636	2381	76.5	1562	50.2
	50–54	3 176 058	4030	126.9	2334	73.5
	55–59	2 803 507	5484	195.6	2777	99.1

Table 1. Continued

Years	Age Range, y	Population, PY	Ischemic Stroke		STEMI	
			Count	Rate (Per 100K PY)	Count	Rate (Per 100K PY)
	60–64	2 329 196	6790	291.5	2806	120.5
	65–69	1 808 249	8694	480.8	2383	131.8
	70–74	1 312 647	9101	693.3	1976	150.5
	75–79	1 019 484	9898	970.9	1748	171.5
	80–84	845 787	10 636	1257.5	1666	197.0

PY indicates person-years; STEMI, ST-segment elevation myocardial infarction.

Table 3 and Figure 1 present data on birth cohorts for stroke and STEMI. For the youngest 3 age groups (35–39, 40–44, and 45–49 years) there were significant increases in the rate of stroke in the last 2 periods of the study, 2005–2009 and 2010–2014, as compared with the first period, 1995–1999. For example, in the 35- to 39-year age group, the rate of stroke increased from 9.5 strokes per 100 000 PY in 1995–1999 to 23.6 strokes per 100 000 PY (rate ratio [RR], 2.47; 95% CI, 2.07–2.96 [$P<0.0001$]). The rates of stroke increase in these age groups were similar in both men and women (data not shown). In contrast, we found declining rates of stroke in the oldest 6 age groups ranging from 55 to 84 years. We found a 22% decrease in the rate of stroke in those 80 to 84 years between 1995–1999 and 2010–2014 (RR, 0.78; 95% CI, 0.74–0.83 [$P<0.0001$]). The rate of STEMI in the 35- to 39-year age group decreased from 21.0 to 13.6 per 100 000 PY from 1995–1999 to 2010–2014 (RR, 0.65;

Table 2. Goodness-of-Fit Comparisons Between Poisson Models Used for Age–Period–Cohort Analyses of Ischemic Stroke and STEMI

Outcome	Model	QIC
Ischemic stroke	Age	−204 240.82
	Age+Drift*	−220 466.43
	Age+Period	−225 289.59
	Age+Cohort	−243 225.57
	Age+Period+Age×Period[†]	−242 798.99
STEMI	Age	−27 090.46
	Age+Drift	−46 891.81
	Age+Period	−47 873.29
	Age+Cohort	−46 182.42
	Age+Period+Age×Period	−48 191.09

QIC indicates quasi-Akaike Information Criterion; STEMI, ST-segment elevation myocardial infarction.
*Drift=use of time period as an ordinal variable.
[†]Interaction term for age and period.

95% CI, 0.50–0.83 [$P=0.001$]). These corresponded with similar, although larger, decreases in STEMI for those aged 80 to 84 years, for whom there was a 71% decrease during these time periods (RR, 0.29; 95% CI, 0.27–0.32 [$P<0.0001$]).

There appeared to be a transition of stroke rates at ages 50 to 54 years. The rate of stroke in those 50 to 54 years decreased significantly between 1995–1999 and 2000–2004 (RR, 0.85; 95% CI, 0.74–0.96 [$P=0.01$] and showed no significant difference between 1995–1999 and 2004–2008 and a small increase between 1995–1999 and 2010–2014. Those aged 50 to 54 years during 2000–2004 were born between 1946 and 1954. This same cohort was 55 to 59 years during 2005–2009 and 60 to 64 years during 2010–2014. The rate of stroke for this cohort was lower than the reference cohort (born 10 years earlier) when this group was 55 to 59 years (RR, 0.81; 95% CI, 0.72–0.91 [$P=0.0004$], compared with 1995–1999) and 60 to 64 (RR, 0.78; 95% CI, 0.70–0.87 [$P<0.0001$], compared with 1995–1999). This distinct cohort effect did not appear in the STEMI data, where the rates declined in all age groups in the second and third time period and showed little or no change between the third and fourth time period.

Birth Cohort Analysis of Stroke and STEMI Incidence Rates

In our second analysis, we examined the birth cohort effect. We limited the ages examined in this model to ages 45 to 65 years since each of the 10-year birth cohorts provided data for these ages during the study period. Those born between 1945 and 1954 (designated as the reference birth cohort) had lower rates of stroke compared with the two prior birth cohorts (those born between 1925–1934 or 1935–1944) and with the two birth cohorts that followed (those born between 1955–1964 or 1965–1974) (Table 4). Those born in the earliest examined birth cohort, 1925–1934, had a 26% higher rate of stroke after adjusting for age compared with those born in 1945–1954 (adjusted RR [ARR], 1.26; 95% CI, 1.15–

Table 3. Age-Period Analyses for Incidence Rate Ratios of Ischemic Stroke and STEMI Comparing Four 5-Year Time Periods for Ten 5-Year Age Groups

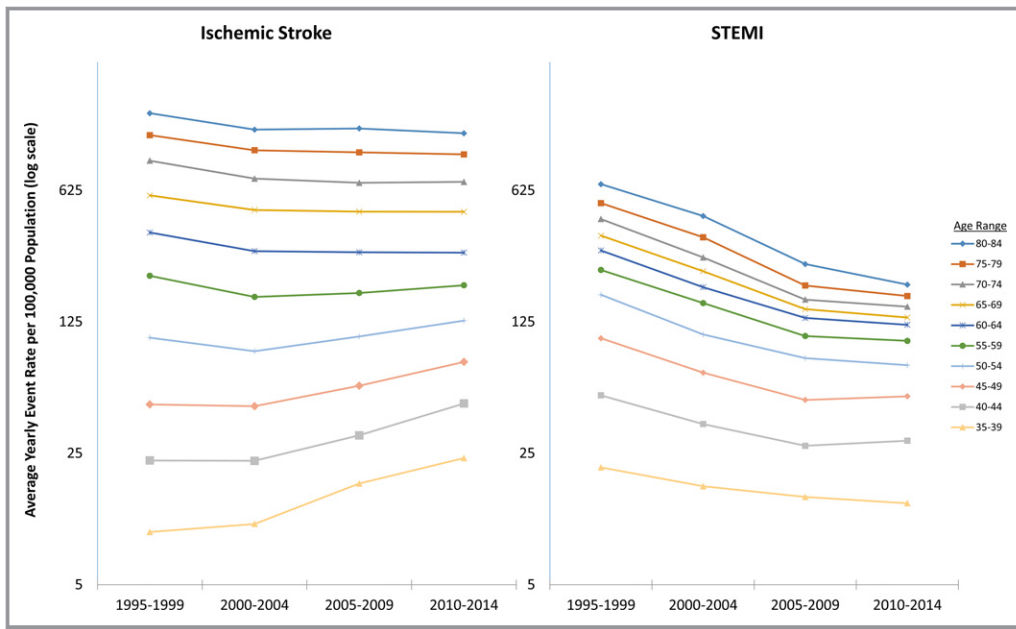| Age Group, y	Comparison	Ischemic Stroke		STEMI	
		Rate Ratio (95% CI)	P Value	Rate Ratio (95% CI)	P Value
35–39	Period 2 vs period 1*	1.10 (0.91–1.34)	0.3	0.79 (0.61–1.04)	0.1
	Period 3 vs period 1	1.81 (1.51–2.17)	<0.0001	0.70 (0.54–0.90)	0.01
	Period 4 vs period 1	2.47 (2.07–2.96)	<0.0001	0.65 (0.50–0.83)	0.001
40–44	Period 2 vs period 1	1.00 (0.85–1.17)	0.9	0.70 (0.55–0.90)	0.01
	Period 3 vs period 1	1.36 (1.16–1.59)	0.0001	0.54 (0.42–0.69)	<0.0001
	Period 4 vs period 1	2.01 (1.71–2.36)	<0.0001	0.57 (0.46–0.72)	<0.0001
45–49	Period 2 vs period 1	0.98 (0.85–1.13)	0.8	0.66 (0.51–0.84)	0.001
	Period 3 vs period 1	1.26 (1.09–1.44)	0.001	0.47 (0.37–0.60)	<0.0001
	Period 4 vs period 1	1.68 (1.46–1.94)	<0.0001	0.49 (0.39–0.62)	<0.0001
50–54	Period 2 vs period 1	0.85 (0.74–0.96)	0.01	0.62 (0.49–0.78)	<0.0001
	Period 3 vs period 1	1.01 (0.89–1.16)	0.8	0.46 (0.37–0.58)	<0.0001
	Period 4 vs period 1	1.23 (1.08–1.40)	0.001	0.42 (0.34–0.52)	<0.0001
55–59	Period 2 vs period 1	0.77 (0.69–0.87)	<0.0001	0.67 (0.54–0.82)	0.0001
	Period 3 vs period 1	0.81 (0.72–0.91)	0.0004	0.45 (0.37–0.54)	<0.0001
	Period 4 vs period 1	0.89 (0.79–1.00)	0.05	0.42 (0.35–0.51)	<0.0001
60–64	Period 2 vs period 1	0.80 (0.72–0.88)	<0.0001	0.64 (0.53–0.76)	<0.0001
	Period 3 vs period 1	0.79 (0.70–0.88)	<0.0001	0.44 (0.37–0.52)	<0.0001
	Period 4 vs period 1	0.78 (0.70–0.87)	<0.0001	0.40 (0.34–0.48)	<0.0001
65–69	Period 2 vs period 1	0.84 (0.76–0.92)	0.0003	0.65 (0.55–0.76)	<0.0001
	Period 3 vs period 1	0.82 (0.74–0.90)	<0.0001	0.41 (0.35–0.48)	<0.0001
	Period 4 vs period 1	0.82 (0.74–0.91)	0.0001	0.37 (0.31–0.43)	<0.0001
70–74	Period 2 vs period 1	0.80 (0.73–0.88)	<0.0001	0.63 (0.55–0.71)	<0.0001
	Period 3 vs period 1	0.76 (0.70–0.83)	<0.0001	0.37 (0.33–0.42)	<0.0001
	Period 4 vs period 1	0.77 (0.70–0.85)	<0.0001	0.34 (0.30–0.39)	<0.0001
75–79	Period 2 vs period 1	0.83 (0.77–0.90)	<0.0001	0.66 (0.59–0.74)	<0.0001
	Period 3 vs period 1	0.81 (0.75–0.88)	<0.0001	0.36 (0.33–0.40)	<0.0001
	Period 4 vs period 1	0.79 (0.73–0.85)	<0.0001	0.32 (0.29–0.36)	<0.0001
80–84	Period 2 vs period 1	0.82 (0.77–0.87)	<0.0001	0.68 (0.62–0.74)	<0.0001
	Period 3 vs period 1	0.83 (0.78–0.89)	<0.0001	0.38 (0.34–0.41)	<0.0001
	Period 4 vs period 1	0.78 (0.74–0.83)	<0.0001	0.29 (0.27–0.32)	<0.0001

STEMI indicates ST-segment elevation myocardial infarction.
*Period 1=1995–1999, period 2=2000–2004, period 3=2005–2009, period 4=2010–2014.

1.38 [P<0.0001]). Those born in the latest birth cohort, 1965–1974, had a 43% higher rate of stroke compared with those born between 1945 and 1954 (ARR, 1.43; 95% CI, 1.21–1.69 [P<0.0001]). In a similar analysis for STEMI, each successive birth cohort had a lower rate of STEMI than the prior birth cohort. For example, those in the latest birth cohort (1965–1974) had a rate of STEMI that was 54% lower than those born in 1945–1954 (ARR, 0.46; 95% CI, 0.36–0.59 [P<0.0001]).

Discussion

In this APC analysis of incident rates of ischemic stroke and STEMI in New Jersey, we found that there was a concerning upward trend in the rate of stroke for those in the 3 youngest age groups, those from age 35 to 49 years. There also appeared to be an age group, 50 to 54 years, where there were relatively modest changes in the rate of stroke throughout the 20 years. The downward trend in the oldest

Figure 1. Age-period incidence rates of ischemic stroke and ST-segment elevation myocardial infarction (STEMI) comparing four 5-year time periods for ten 5-year age groups.

age groups, the flattening trend in the middle age groups, and the upward trend in the youngest age groups suggest a birth cohort effect. In a direct analysis of birth cohorts, we found that those born from 1945 to 1954 had a significantly lower risk of stroke compared with earlier and later cohorts after adjusting for age; an effect that was not evident for STEMI (Figure 2). This finding seems to indicate a possible transition in birth cohort effects on stroke risk.

Other research has suggested similar trends in stroke risk. Khellaf et al, examining data from Dijon, France, from 1985–2005 and using APC analysis, found that men aged 18 to 59 years had an increased risk for stroke between 1992–1998 and 1999–2005.[13] They did not find a similar effect in women. Kissela et al found increases in stroke rates in both

white and black patients aged 20 to 54 years between 1993 and 2005.[12] The results from our study provide additional evidence for the trend of increasing rates of stroke in patients 50 years and younger.

We found evidence that those born between 1945 and 1954 had significantly lower rates of stroke after age adjustment. Compared with the earlier birth cohorts, the 1945–1954 cohort had lower prevalence of obesity and smoking.[24,25] They also benefited from the availability of lipid–lowering drugs such as statins and antihypertensive agents such as angiotensin-converting enzyme inhibitors earlier in their lifetimes than prior cohorts.[26,27] While this cohort had a higher prevalence of diabetes than its predecessors, these had not yet reached the epidemic proportions found in later

Table 4. Birth Cohort Analysis for Incidence Rate Ratios of Ischemic Stroke and STEMI Comparing Patients Born From 1945 to 1954 With Earlier and Later Birth Cohorts in Ages 45 to 65 Years

Birth Cohort Comparison	Ischemic Stroke		STEMI	
	Adjusted Rate Ratio* (95% CI)	P Value	Adjusted Rate Ratio* (95% CI)	P Value
1925–1934 vs 1945–1954	1.26 (1.15–1.38)	<0.0001	2.56 (2.17–3.03)	<0.0001
1935–1944 vs 1945–1954	1.11 (1.06–1.17)	<0.0001	1.70 (1.54–1.88)	<0.0001
1955–1964 vs 1945–1954	1.17 (1.10–1.25)	<0.0001	0.62 (0.55–0.69)	<0.0001
1965–1974 vs 1945–1954	1.43 (1.21–1.69)	<0.0001	0.46 (0.36–0.59)	<0.0001

STEMI indicates ST-segment elevation myocardial infarction.
*Adjusted for age.
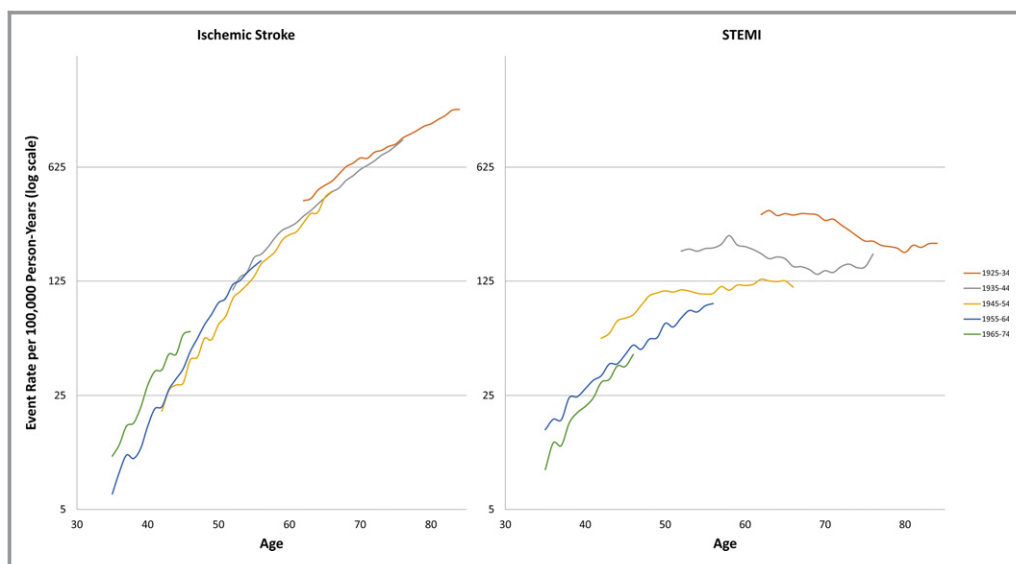
Figure 2. Birth cohort incidence rates of ischemic stroke and ST-segment elevation myocardial infarction (STEMI) for five 10-year birth cohorts.

cohorts.[28] The 1945–1954 birth cohort also likely benefited from the widespread improvement in the understanding of and treatment for risks related to all cardiovascular disease.

We also found evidence that those born after 1954 had higher rates of stroke compared with the 1945–1954 birth cohort. In these later cohorts, there was a reversal in the trend toward lower prevalence of obesity as well as a much steeper increase in the prevalence of diabetes.[24,28] It has also been shown that, in spite of advanced treatment options, control of blood pressure and plasma lipids is lower in the younger age groups during the time period of this study.[29–32] Medication adherence has been shown to be lower in those without health insurance,[33] and the younger birth cohorts were less likely to have health insurance than those born earlier.[34] Atrial fibrillation, a leading risk factor for stroke, has also been steadily increasing in younger individuals, possibly because of the increase in obesity.[35] These factors may help to explain the rising rates in stroke among the later births cohorts.

There was a significant downward trend in the rate of STEMI for all age groups and in the rate of stroke in the older age groups. It is important to try to understand the differences in the rates of stroke and STEMI in the young. While stroke rates showed increasing trends during the study period in those younger than 50 years, STEMI rates declined for the first 15 years of the study and remained constant for the final 5 years. Stroke may be more related to control of hypertension, whereas STEMI is more associated with plasma lipid levels.[36–39] As previously discussed, hypertension has been shown to be less well controlled in younger versus older age groups. In addition, the increasing prevalence of atrial

fibrillation in the young would have a greater impact on rates of stroke than those of STEMI.[40] While it is important to understand the differences in stroke versus STEMI rate changes in the young, it is also interesting that there appears to be a trend towards slowing in the decline of rates of STEMI in the younger age groups. These early trends may have significant implications for the future.

Study Strengths

This study has a number of strengths. The data utilized were from a large data set collected during 20 years. The accuracy of the diagnoses for both STEMI and stroke have been previously validated.[16] New Jersey has a large, diverse population with proportions of young and old and whites, African Americans, and Hispanics similar to the overall United States.[41] In addition, health insurance coverage rates are similar in New Jersey as in the rest of the United States.[42] Thus, our results could be generalizable to other areas in the United States.

Study Limitations

There are several limitations to this study. The data were from an administrative source where diagnostic coding is intended for healthcare reimbursement and could include a significant rate of miscoding.[43] However, the probability of miscoding for MI and stroke is likely very low, as studies have found the sensitivity and specificity for these two diagnoses in administrative records to be near or above 90%.[43,44] During the

course of this study, there have been changes in the use of magnetic resonance imaging, raising the possibility of ascertainment bias in stroke diagnoses. However, a recent study by Kleindorfer and colleagues[45] found minimal differences in stroke discharge diagnoses with the use of magnetic resonance imaging. Whether there could be secular shifts in the probability of being hospitalized for minor stroke, and whether such admission practices might differ by age, is not known. We do not have data on emergency services response time for stroke patients. It may be possible that if response times were better in younger versus older patients than this could account for some of the increase in stroke rates as measured by hospital admissions. However, the data on differential response rates by age are equivocal. Several studies have found response rates to be better, worse, or no different in older versus younger patients.[46–48]

Conclusions

The results from this study beg the question: "Has the 'stroke-healthiest' generation come and gone?" Based on our findings, there appears to a trend toward increasing rates of ischemic stroke in those born after 1954. We also found a slowing of the trend of decreasing STEMI rates, particularly in those younger than 50 years. These trends may have significant implications for health outcomes and the overall healthcare burden in the future. Further analyses of these outcomes in persons younger than 55 years should be done in other populations to assess their reproducibility. Examination of cohorts that have been under close observation for proven or suspected stroke, regardless of hospitalization, is also needed. The present finding of increasing stroke rates in persons younger than 55 years is unsettling and merits vigorous inquiry.

Appendix

Contributors from the MIDAS study group: Javier Cabrera, John Pantazopoulos, and Davit Sargsyan.

Disclosures

None.

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