



## Incidence of Parkinson's Disease: Variation by Age, Gender, and Race/Ethnicity

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The goal of this study was to estimate the incidence of Parkinson's disease by age, gender, and ethnicity. Newly diagnosed Parkinson's disease cases in 1994–1995 were identified among members of the Kaiser Permanente Medical Care Program of Northern California, a large health maintenance organization. Each case met modified standardized criteria/Hughes diagnostic criteria as applied by a movement disorder specialist. Incidence rates per 100,000 person-years were calculated using the Kaiser Permanente membership information as the denominator and adjusted for age and/or gender using the direct method of standardization. A total of 588 newly diagnosed (incident) cases of Parkinson's disease were identified, which gave an overall annualized age- and gender-adjusted incidence rate of 13.4 per 100,000 (95% confidence interval (CI): 11.4, 15.5). The incidence rapidly increased over the age of 60 years, with only 4% of the cases being under the age of 50 years. The rate for men (19.0 per 100,000, 95% CI: 16.1, 21.8) was 91% higher than that for women (9.9 per 100,000, 95% CI: 7.6, 12.2). The age- and gender-adjusted rate per 100,000 was highest among Hispanics (16.6, 95% CI: 12.0, 21.3), followed by non-Hispanic Whites (13.6, 95% CI: 11.5, 15.7), Asians (11.3, 95% CI: 7.2, 15.3), and Blacks (10.2, 95% CI: 6.4, 14.0). These data suggest that the incidence of Parkinson's disease varies by race/ethnicity.

age factors; ethnic groups; incidence; Parkinson disease; racial stocks; sex

Abbreviations: CI, confidence interval; KPMCP, Kaiser Permanente Medical Care Program.

Whether or not Parkinson's disease frequency varies by race/ethnicity or gender has been a source of controversy for many decades (1–6). Resolution of this dispute has in the past relied on prevalence data or clinical populations to render conclusions (1, 5, 7, 8). Prevalence data lack the ability to sort out the joint influence of incidence and survival, whereas studies conducted among clinical or referral series may include patients not representative of the total population with the disease. Furthermore, because Parkinson's disease is a disease of the elderly, a time when survival is known to vary by gender and race/ethnicity, prevalence data are not reliable surrogates for incidence.

The scarcity of incidence data on Parkinson's disease in general has primarily been the result of the difficulties in identifying a sufficiently large number of affected individ-

uals in a well-defined or enumerated population. The major problems are the low frequency of Parkinson's disease and the difficulty in establishing diagnosis. These factors, along with the absence of population-based disease registries, have significantly contributed to the lack of good knowledge for even the most basic descriptive epidemiologic characteristics. Parkinson's disease incidence has been estimated in only about five studies to date, and in only one were rates estimated for more than one race/ethnicity (6). In all, rates were estimated based on relatively few Parkinson's disease cases, and precision was limited, especially in the oldest age groups.

The few incidence studies that have been published have shown that the rate of Parkinson's disease rises sharply after

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the fifth decade, although whether there is a progressive rise in late life or a decline in incidence remains controversial (6, 9, 10). Gender differences have been reported in most studies, with men having higher rates (6, 10). North American incidence data by race/ethnicity are limited to a single study conducted in northern Manhattan, New York, New York (6). In this area, the incidence rates were highest in Blacks compared with Whites, primarily because of a large excess among young Black men. This observation contradicts most, but not all, studies estimating Parkinson's disease prevalence, which have reported lower prevalence rates among Blacks compared with Whites (1–6). Whether Parkinson's disease is indeed more common among Blacks, but underreported, or whether some characteristics of the latter study resulted in overestimation of Parkinson's disease frequency in Blacks remains a question.

To address this important issue, we sought to estimate the incidence rates of Parkinson's disease in a large prepaid health maintenance organization with a multiethnic population of sufficient size to increase precision and without economic barriers limiting access to care. Specific focus was directed at estimating the incidence of Parkinson's disease by race/ethnicity, gender, and age.

## MATERIALS AND METHODS

### Setting

The base population for this study was the membership of the Kaiser Permanente Medical Care Program (KPMCP), northern California, a large group practice model prepaid health maintenance organization. KPMCP provides comprehensive medical and health services through 17 medical center hospitals and 21 medical office buildings to over 2.4 million members primarily located in the urban areas around the greater San Francisco Bay and Sacramento metropolitan areas. Approximately 25–30 percent of the population in these geographic areas belongs to the health plan. A comparison of KPMCP data and Bay Area metropolitan statistical area census data demonstrates that KPMCP is closely representative of the general population in a number of demographic and socioeconomic categories, including gender and race/ethnicity (11, 12). Internal survey data show that the KPMCP membership reflects a broad household income range and is representative of the geographic area except for having a slightly higher education and income level (12). This study was conducted with approval from the Institutional Review Board of the Kaiser Foundation Research Institute.

During this study, neurologic care was provided by over 50 neurologists who were all Kaiser Permanente physicians. Referral to a neurologist is made by the primary care provider, and a pilot study found that neurologists see 91 percent of newly diagnosed Parkinson's disease patients within 5 months of the primary care provider's first noting parkinsonism, with the median time being 27 days. Thus, specialist care for these patients appears to begin early in the disease course.

### Case definition

Cases were defined as members of KPMCP, who were diagnosed with idiopathic Parkinson's disease between January 1, 1994, and December 31, 1995. All cases had to meet modified Core Assessment Program for Intracerebral Transplantation (CAPIT)/Hughes diagnostic criteria (13, 14) at the time of diagnosis and within the study period, according to the following symptoms: 1) the presence of at least two of the following signs: resting tremor, cogwheel rigidity, bradykinesia, and postural reflex impairment, at least one of which must be either resting tremor or bradykinesia; 2) no suggestion of a cause for another parkinsonian syndrome such as drugs, trauma, brain tumor, or treatment within the last 12 months with dopamine-blocking or dopamine-depleting agents; and 3) no atypical features such as prominent oculomotor palsy, cerebellar signs, vocal cord paresis, severe orthostatic hypotension, pyramidal signs, amyotrophy, or limb apraxia. This approach has been recommended for use in epidemiologic studies (15).

### Case identification

Multiple methods of case finding were used to ascertain *potential* incident Parkinson's disease cases. First, regular surveillance of computerized databases for Parkinson's disease or related disorders was conducted. These databases included the outpatient and inpatient utilization databases and an administrative database to monitor utilization and billing for non-KPMCP health care for which KPMCP is financially responsible. The former two databases are used to track each outpatient and inpatient visit or encounter, including clinic, physical therapy care, emergency department, urgent care, outpatient surgery visits, and hospitalizations at KPMCP facilities. The latter database tracks utilization and billings for those who are referred by a KPMCP clinician to a non-plan provider or facility or those that required emergency services in a non-KPMCP facility. Potential incident Parkinson's disease cases were identified from inpatient and outpatient utilization databases using the *International Classification of Diseases* system (16) diagnostic codes for Parkinson's disease (code 332.0), central or unspecified tremor (code 331.0), other degenerative disorders of the basal ganglia (code 333.0), and all individuals with a diagnostic code of 332.x. In addition, the KPMCP computerized pharmacy system was reviewed approximately every 2 weeks to identify persons receiving antiparkinsonian drug prescriptions. These drugs included levodopa, carbidopa-levodopa, bromocriptine, selegiline, amantadine, pergolide, and, more recently, pramipexole, ropinirole, and tolcapone. A second method of case identification was to elicit study referrals from KPMCP physicians treating Parkinson's disease patients. All neurologists in KPMCP were notified of the study and asked to refer newly diagnosed Parkinson's disease patients. Referrals to the study could be either by a specifically designed referral card sent to the study staff or by a telephone referral to a study telephone line and voice mail. Some neurologists maintain a patient registry for their own use, and lists of Parkinson's disease patients were obtained from these physicians. Study

newsletters were used to maintain clinician interest in the study.

### Case confirmation

Each potentially eligible subject underwent a standard process to confirm the diagnosis and to determine if study criteria were satisfied for classification as an incident case in the study period. Each potential case was first linked to a prevalent Parkinson's disease database, which was established to include KPMCP patients known to have been diagnosed with Parkinson's disease prior to 1994. Any potentially eligible patient who matched up to an entry in the prevalence database was removed from further consideration. All remaining potentially eligible cases underwent a case confirmation procedure. This procedure involved first the abstracting of neurologic and other Parkinson's disease-related notes from the medical record by a trained medical record analyst. In addition, relevant data from computerized utilization and pharmacy records were evaluated. These abstracted medical records were then reviewed by a movement disorders specialist (C. M. T.) who determined if diagnostic criteria were met. If information available in the medical record was insufficient to meet the criteria, additional information was obtained by waiting for additional visits to a physician and abstracting the data. This was supplemented in some cases by contacting the treating physician directly.

### Data collection

Race, gender, and age data for 86.5 percent of the eligible cases were obtained from direct interview as part of a case-control study. For Parkinson's disease cases who were not interviewed as part of the etiologic study, this information came from either utilization databases that collect race/ethnicity (e.g., the hospitalization records) or the medical record directly. Race/ethnicity was categorized as non-Hispanic White, Black, Hispanic, Asian/Pacific Islander, and other. The latter category included Native Americans ( $n = 3$ ) and unknown ( $n = 1$ ). Denominator data from the study population were obtained principally from computerized databases used as administrative records to record membership and include information on membership status, birth date, and gender. Administrative database records were used for the crude, age-, and gender-stratified analyses. Because of enrollment and disenrollment in the health plan by members, person-years were calculated from monthly membership records and used for the denominator in all calculations. Because race/ethnicity data are not routinely collected on all KPMCP members, several data sources were used to obtain this information. Race/ethnicity-specific denominators were estimated by applying the race/ethnicity distribution data obtained for a sample of 33,560 randomly selected adult members of the health plan. Race/ethnicity data were taken primarily from survey data and utilization databases for this sample. The survey data were designed to obtain prevalence-of-illness and satisfaction data on a representative sample of the population over the age of 20 years. Race/ethnicity data were available in this sample for 84.7

**TABLE 1. Parkinson's disease cases and population by gender, age, race/ethnicity, and year, Kaiser Permanente, 1994–1995**

	Total	Total person-years
Overall	588	4,776,038
Gender (all ages)		
Female	230	2,461,498
Male	358	2,314,540
Age (years)		
30–39	4	793,460
40–49	20	810,224
50–59	55	560,856
60–69	154	397,230
70–79	259	241,623
≥80	96	80,667
Race/ethnicity*		
Non-Hispanic White	474	2,008,081
Black	28	229,089
Asian	35	324,475
Hispanic/Latino	47	299,343
Other	4	23,070

\* Person-years by race/ethnicity are for age 30 years or older.

percent of members over 30 years of age and for 93.1 percent of members over 50 years of age. The race/ethnicity distribution by age and gender from these data was then applied to the complete age and gender membership data to arrive at final denominator data for the race/ethnicity analyses. Analyses limited to age and/or gender used actual membership data.

### Statistical methods

Crude and adjusted annual rates were calculated per 100,000 person-years (17). Age- and/or gender-adjusted rates and 95 percent confidence intervals were calculated using direct standardization (17) with the age and/or gender distribution of the 1990 US population (18) as the reference population.

### RESULTS

The case ascertainment methods used in this study found 588 cases of incident Parkinson's disease who met modified Core Assessment Program for Intracerebral Transplantation/Hughes criteria at the time of diagnosis in 1994 and 1995 among the Kaiser Permanente northern California population. The distribution by age, gender, and race/ethnicity for cases and the population at risk is presented in table 1. The mean age at diagnosis was 70.5 (range, 38–91) years for men and 70.5 (range, 31–93) years for women. Non-Hispanic Whites were significantly older at diagnosis than either Hispanics or Asian/Pacific Islanders, and they were slightly but not significantly older than Blacks (data not shown).

**TABLE 2. Annual incidence rate\* of Parkinson's disease by gender and age, all ethnic groups combined, Kaiser Permanente, 1994–1995**

Age (years)	Female				Male				Male: female ratio	Total	
	Cases (no.)	Person-years	Rate	95% CI†	Cases (no.)	Person-years	Rate	95% CI		Rate	95% CI
<30	0	949,294	0		0	942,684	0			0	
30–39	2	411,382	0.5	0.0, 1.2	2	382,078	0.5	0.0, 1.2	1.0	0.5	0.0, 1.5
40–49	7	424,714	1.6	0.4, 2.9	13	385,510	3.4	1.5, 5.2	2.1	2.5	1.0, 3.9
50–59	25	290,733	8.6	5.2, 12.0	30	270,123	11.1	7.1, 15.1	1.3	9.8	7.6, 12.1
60–69	60	207,209	29.0	21.6, 36.3	94	190,021	49.5	39.5, 59.5	1.7	38.8	35.3, 42.2
70–79	102	130,053	78.4	63.2, 93.6	157	111,570	140.7	118.7, 162.7	1.8	107.2	102.1, 112.2
80–89	34	48,113	70.7	46.9, 94.4	62	32,554	190.5	143.1, 237.8	2.7	119.0	112.2, 125.8
Overall	230	2,461,498	9.9‡	7.6, 12.2	358	2,314,540	19.0‡	16.1, 21.8	1.9	13.4§	11.4, 15.5

\* Incidence rates are per 100,000 person-years.

† CI, confidence interval.

‡ The overall gender-specific incidence rates are age adjusted to the 1990 US population.

§ Age and gender adjusted to the 1990 US population.

The crude overall annual incidence rate was 12.3 per 100,000, while for persons over 50 years of age the crude incidence was 44.0 per 100,000. Overall, the age- and gender-adjusted incidence rate was 13.4 per 100,000 (95 percent confidence interval (CI): 11.4, 15.5). The age-adjusted incidence rate for men was 19.0 per 100,000 (95 percent CI: 16.1, 21.8), and for women it was 9.9 per 100,000 (95 percent CI: 7.6, 12.2) (male:female ratio = 1.9).

Table 2 shows the incidence by age for men and women. The incidence rates for both men and women rose rapidly after the age of 60 years. Interestingly, the male:female ratio also generally increases with age. The overall incidence increases with age, going from 0.50 per 100,000 in the 30- to 39-year category to 119.01 per 100,000 in the oldest age category. This same pattern was observed among men and women, except for a slight drop in the incidence rate for the 80- to 89-year age category among women.

The incidence rates by race/ethnicity and gender are presented in table 3. The age- and gender-adjusted incidence rates were highest among Hispanics, followed by non-Hispanic Whites, Asians, and Blacks. No comparisons of age- and gender-adjusted incidence rates between individual groups were statistically significant; however, several of the pairwise comparisons were of borderline statistical significance (i.e., non-Hispanic White vs. Asian, 13.6 vs. 11.3 per 100,000,  $p = 0.07$ ; Hispanic vs. Asian, 16.6 vs. 11.3 per 100,000,  $p = 0.10$ ; non-Hispanic White vs. Black, 13.6 vs. 10.2 per 100,000,  $p = 0.11$ ). In all groups other than Asians, the incidence of Parkinson's disease among men was approximately twofold higher than the incidence among women. Among Asians, however, Parkinson's disease incidence was slightly lower among men than women.

## DISCUSSION

This is the first study to provide estimates of incidence in all four of the most common US race/ethnicity groups. In

addition, these estimates are based on nearly four times the number of incident Parkinson's disease cases and over three times the number of person-years compared with the next largest study. All prior reports on Parkinson's disease frequency by race/ethnicity have been on one race/ethnicity group (9, 19), except a report of the incidence among Blacks, Whites, and "other" in northern Manhattan, New York (6). One other study also estimated Parkinson's disease prevalence among Blacks and Whites (5).

These trends in the data suggest that disease rates among Asians appear to be lower than those of Whites, whether they be non-Hispanic or Hispanic Whites. Furthermore, Parkinson's disease rates among Blacks are likely to be lower than those among non-Hispanic Whites, consistent with several past prevalence studies (1–6). We were not able to replicate the findings from a recent study that found higher Parkinson's disease incidence among Blacks (6); methodological differences may explain this disparity. Mayeux et al. (6) reported that the highest incidence was among young Black men in a population in northern Manhattan. Their study identified a total of 24 Black cases over the 3-year ascertainment period. Data from the 1990 Census for the Washington Heights' section of northern Manhattan were used to estimate the denominators by race/ethnicity and for age adjustment. We adjusted their rates and ours using the same reference population (e.g., the 1990 US Census) to allow comparisons (table 4). The overall incidence rate for Black men in northern Manhattan was over twice as high as our rate for Black men (31.2 vs. 14.0 per 100,000, respectively), whereas the rates for Black women were comparable (10.1 per 100,000 in northern Manhattan and 8.1 per 100,000 in northern California). Likely explanations for the difference may be variation in population characteristics and exposures, case-finding methods, and limitations in denominator accuracy for both studies. With regard to the latter, in both studies underascertainment of minority members of the base population was likely. In northern Manhattan, this

**TABLE 3. Age-specific and age-adjusted annual incidence rate\* of Parkinson's disease by gender and race/ethnicity, Kaiser Permanente, 1994–1995**

Race/ethnicity and age (years)	Female					Male					Male: female ratio	Total		
	Cases (no.)	Person-years	Age-specific rate	Age-adjusted rate†	95% CI‡	Cases (no.)	Person-years	Age-specific rate	Age-adjusted rate†	95% CI		Age-specific rate	Age- and gender-adjusted rate§	95% CI
<b>Non-Hispanic White</b>														
30–39	2	248,177	0.81			0	246,535	0.00				0.40		
40–49	4	274,203	1.46			8	266,945	3.00			2.1	2.22		
50–59	15	210,674	7.12			21	194,732	10.78			1.5	8.88		
60–69	46	154,803	29.72			75	141,661	52.94			1.8	40.81		
70–79	88	108,293	81.26			131	91,473	143.21			1.8	109.63		
≥80	28	42,647	65.66			56	27,940	200.43			3.1	119.00		
Total	183	1,038,797		9.9	7.4, 12.3	291	969,286		19.5	16.5, 22.5	2.0		13.6 11.5, 15.7	
<b>Black</b>														
30–39	0	38,881	0.00			0	28,271	0.00				0.00		
40–49	0	39,778	0.00			1	28,720	3.48				1.46		
50–59	2	23,321	8.58			3	22,707	13.21			1.5	10.86		
60–69	3	13,845	21.67			3	14,406	20.82			1.0	21.24		
70–79	5	8,217	60.85			5	6,366	78.54			1.3	68.57		
≥80	2	2,747	72.81			4	1,830	218.58			3.0	131.09		
Total	12	126,789		8.1	3.9, 12.3	16	102,300		14.0	8.7, 19.2	1.7		10.2 6.4, 14.0	
<b>Asian</b>														
30–39	0	55,424	0.00			0	45,404	0.00				0.00		
40–49	1	59,291	1.69			3	45,534	6.59			3.9	3.82		
50–59	6	31,381	19.12			1	29,091	3.44			0.2	11.58		
60–69	3	22,199	13.51			4	17,434	22.94			1.7	17.66		
70–79	5	7,381	67.74			9	8,162	110.27			1.6	90.07		
≥80	2	1,322	151.29			1	1,852	54.00			0.4	94.52		
Total	17	176,998		11.1	6.2, 16.0	18	147,477		10.8	6.3, 15.4	1.0		11.3 7.2, 15.3	
<b>Hispanic/Latino</b>														
30–39	0	64,808	0.00			1	57,539	1.74				0.82		
40–49	2	47,257	4.23			1	40,355	2.48			0.6	3.42		
50–59	2	23,482	8.52			5	21,837	22.90			2.7	15.45		
60–69	8	15,665	51.07			12	15,287	78.50			1.5	64.62		
70–79	4	5,772	69.30			10	5,297	188.79			2.7	126.48		
≥80	1	1,147	87.18			1	897	111.48			1.3	97.85		
Total	17	158,131		11.9	6.8, 17.1	30	141,212		23.0	16.8, 29.2	1.9		16.6 12.0, 21.3	

\* Incidence rates are per 100,000 person-years.

† The overall gender-specific incidence rates are age adjusted to the 1990 US population.

‡ CI, confidence interval.

§ Age and gender adjusted to the 1990 US population.

would be due to undercounts of minorities in the census data (20) and in our study the result of differential response to the survey. In either case, such underascertainment would lead to an overestimation of the rate. The relative differences in rates, at least in part, could be explained by differential underascertainment between the two studies. In addition, differences in the methods of case finding could potentially influence relative incidence rates between the studies.

In our population, Parkinson's disease incidence among Asian/Pacific Islanders (age- and gender-adjusted incidence =

11.3, 95 percent CI: 7.2, 15.3) was similar to that of non-Hispanic Whites. The investigators of the Honolulu Heart Study reported an age-adjusted incidence of 11.1 per 100,000 for the 92 cases of incident Parkinson's disease among a cohort of 8,006 men of Japanese or Okinawan ancestry that have been followed since 1965 (9). After adjustment to the same standard population, our rate for Asian/Pacific Islander men was lower (10.8 per 100,000, 95 percent CI: 6.3, 15.4) than that found in Hawaii (13.1 per 100,000, 95 percent CI: 10.6, 15.6) (table 4). This may be due, in part, to differences

TABLE 4. Incidence\* of Parkinson's disease by study

Study location, time period, first author (reference no.)	Race/ethnic group	No. of Parkinson's disease cases	Rate in men per 100,000*	95% CI†	Rate in women per 100,000*	95% CI	Age- and gender-adjusted incidence rate per 100,000*	95% CI
Carlisle, England, 1955–1961, Brewis (35)‡	White	60	Not reported		Not reported		11.0	1.8, 20.3
Netherlands, 1983–1985, Hofman (10)§	White	51	11		12		N/A†	
Honolulu Heart Study, 1965–1994, Morens (9)¶	Japanese American, Okinawan	92	13.1		N/A		13.1	10.6, 15.6
Northern Manhattan, New York, NY, 1989–1991, Mayeux (6)#	Overall	83	17.8	13.1, 22.5	11.9	8.3, 15.5	13.9	9.9, 18.0
	Blacks	24	31.2	23.2, 39.1	10.1	5.6, 14.6	18.0	12.0, 24.0
	Whites	46	13.8	9.2, 18.5	13.1	9.3, 16.8	12.9	8.6, 17.3
	Other	13	11.9	5.6, 18.3	12.5	7.7, 17.4	11.8	6.2, 17.5
Rochester, MN, 1976–1990, Bower (19)**	White	154	19.7	15.6, 23.7	9.6	6.9, 12.3	14.0	10.4, 17.9
Kaiser Permanente, 1994–1995, Van Den Eeden††	Overall	588	19.0	16.1, 21.8	9.9	7.6, 12.2	13.4	11.4, 15.5
	Blacks	28	14.0	8.7, 19.2	8.1	3.9, 12.3	10.2	6.4, 14.0
	Non-Hispanic Whites	474	19.5	16.5, 22.5	9.9	7.4, 12.3	13.6	11.5, 15.7
	Hispanics	47	23.0	16.8, 29.2	11.9	6.8, 17.1	16.6	12.0, 21.3
	Asian/Pacific Islander	35	10.8	6.3, 15.4	11.1	6.2, 16.0	11.2	7.2, 15.3

\* All rates adjusted to the 1990 US Census. Published age categories differed by study.

† CI, confidence interval; N/A, not applicable.

‡ Age categories were 0–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years.

§ Age distribution not presented in paper and, thus, not possible to age adjust.

¶ Age distribution was 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, 85–89, and 90–94 years.

# Age categories were 0–44, 45–64, 65–74, 75–84, and ≥85 years.

\*\* Age categories were 0–29, 30–49, 50–59, 60–69, 70–79, and 80–99 years.

†† Age categories were 0–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years.

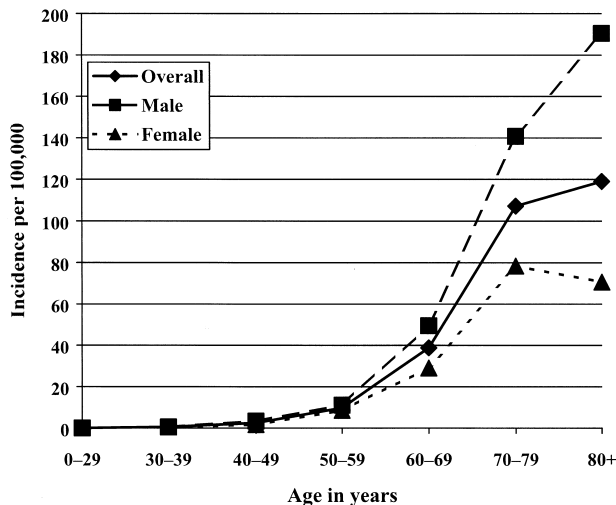
in the ancestry of the two groups, as members of the Kaiser Permanente population included those from or with ancestry from many Asian and Pacific Island areas.

No other study has directly reported the incidence of Parkinson's disease among Hispanic/Latino individuals. However, the "other" category in the northern Manhattan study was stated to be composed of primarily Hispanic individuals (6). The age-adjusted incidence for men was 11.9 (95 percent CI: 5.6, 18.3) and 23.0 (95 percent CI: 16.8, 29.2) in northern Manhattan and in our study, respectively (table 4). For women, the comparable estimates were 12.5 (95 percent CI: 7.7, 17.4) and 11.9 (95 percent CI: 6.8, 17.1). The overall incidence rate for Hispanics was the highest among the race/ethnic groups in our study. The high observed rate and the fact that it was observed among both men and women raise interesting issues regarding possible explanations that are discussed below.

Other studies among predominately White populations have reported incidence rates ranging from 11.0 to 14.0 per 100,000 (table 4). Recent studies in Olmsted County, Minnesota, and northern Manhattan, New York, had age- and

gender-adjusted incidence rates (to the 1990 US Census) for Whites of 14.0 and 12.9 per 100,000, respectively, and our study is consistent with these results (incidence = 13.5 per 100,000) (table 4).

As in all other studies across race/ethnicity, our study found that the incidence rises with age. In most studies, the incidence has been shown to rise with age, with rapid increases after the age of 60 years. Overall, the incidence was greater with each increasing age category, consistent with Parkinson's disease being a result of an early aging phenomenon, at least in part. Parkinson's disease onset rarely occurred before age 40 years in our study, confirming prior work (6, 9, 10, 19), and the Parkinson's disease incidence rose after the age of 55 years with a sharp increase after the age of 60 years. Although interest in disease onset among very young individuals is growing, in our population about 0.5 percent of the cases were diagnosed with Parkinson's disease before age 40 years and 3.4 percent before age 50 years. Over 60 percent of our cases were first diagnosed between the ages of 65 and 79 years. Our data also show that the male:female ratio was 1.9 but that this relation



**FIGURE 1.** Incidence of Parkinson's disease by age and gender, Kaiser Permanente, 1994–1995.

varied by age (figure 1). These data are similar to those reported for Rochester, Minnesota (19). Most notable was the similarity in incidence between men and women among Asian/Pacific Islanders in our study population (table 3). Our overall findings with respect to age and gender are consistent with clinical observations as well as with almost all studies of prevalence and incidence (1, 6, 9, 10, 19, 21).

These differences in rates by age, gender, and/or race/ethnicity could be due to real or methodological issues. Variations in host or environmental exposures between the various populations studied could explain some or all of the differences. For example, the category of Asian/Pacific Islander in our study is composed largely of Chinese and Filipinos, while the study by Morens et al. (9) was composed solely of Japanese Americans. In addition, the category of Blacks in the United States includes both African Americans and individuals born in the Caribbean islands and on the African continent. The study by Mayeux et al. (6) likely includes more of the latter than our study did. These types of group differences can represent variation in environmental or personal exposures (e.g., smoking, diet) that may account for some of the observed differences across studies. Although no clear genetic risk factors for idiopathic cases have been elucidated to date, one cannot rule out the possibility of differences in the distribution by race/ethnicity of any susceptibility genes that have yet to be uncovered. Methodological differences may also account for the differences noted. Use of slightly different case definitions, methods of case ascertainment and review (e.g., confirmation), and source of Parkinson's disease cases and denominator populations may all contribute to at least some of the variation observed. In addition, the fact that some of these studies are based on small cohorts or populations with cases identified over a very long period of time (9, 10, 19) or on larger populations studied for shorter periods (6) may result in uncertainty in incidence estimates. Our study had approximately 5

million person-years or over three times the person-years of follow-up compared with the next largest study.

Several aspects of our study need to be kept in mind when considering these results. First, although vigorous efforts were made to find all eligible cases, we expect that the combination of many case-finding methods, though quite successful, still may have missed some cases. In particular, Parkinson's disease case finding in the oldest old of the KPMCP, like all other studies, is difficult. These reasons have been discussed before (9, 15) but include diagnostic uncertainty; provider, family, and patient concern directed at other more serious comorbidities; and delayed diagnosis by primary care providers. As noted in a population-based survey, the prevalence of parkinsonian signs increases with age (22). Although KPMCP has some or all health care responsibility for individuals who reside in nursing homes, we were limited to identifying cases where the clinician has made at least a preliminary finding of Parkinson's disease or where antiparkinsonian drugs had been used. Despite these concerns, the age-adjusted incidence rate for non-Hispanic Whites in our study (13.6 per 100,000) was essentially identical to the rate most recently reported for Olmsted County, Minnesota (13.5 per 100,000) (19), where case ascertainment is recognized as being excellent. A second concern involves our reliance on survey data to estimate the race/ethnicity denominator data. From other work, we have determined that this might have the effect of undercounting non-White members, because these groups were somewhat less likely to be survey responders. If this were the case, our results would underestimate the incidence for non-Hispanic White members and overestimate the rates for undercounted non-White members and further put our results at odds with studies that report non-White incidence to be higher than White rates. It bears keeping in mind that the incidence rates by age, gender, and overall in table 2 are based on actual counts for the population at risk, since membership in KPMCP is well defined on these characteristics. Finally, although this study was multiethnic, the number of cases in the non-White groups was relatively small; either conducting a larger study or adding more years to the current study would have resulted in more precise estimates. Furthermore, although we believe the KPMCP membership to be broadly representative of the underlying population, certain subgroups (e.g., farmers or farm workers) are likely to be underrepresented. This may potentially affect generalizing our results to the full US population as some (putative) exposures vary by such groups.

The differences we observed between these studies may yield useful clues about the determinants of Parkinson's disease. Although genetic factors have been found to strongly influence the occurrence of Parkinson's disease in a small number of individuals or kindreds (23), possible susceptibility genes that affect the risk of developing sporadic (e.g., nonfamilial) Parkinson's disease are under active investigation. In addition, exposure to environmental factors that have been associated with Parkinson's disease risk may vary across these populations. Such factors may include exposure to pesticides (24–26), occupational exposures (27, 28), cigarette smoking (29–31), or dietary factors (32–34). Studies to investigate these and other factors are

underway within our setting as well as others using both case-control and prospective study designs. Further investigations that include incidence estimates and etiologic studies in multiethnic populations will be critical to address these issues.

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