

The Epidemiology of Type 1 Diabetes in Children in Philadelphia 1990–1994

Evidence of an epidemic

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OBJECTIVE — To determine the epidemiology of type 1 diabetes in children in Philadelphia from 1990 to 1994, and to identify whether an epidemic occurred during that time period.

RESEARCH DESIGN AND METHODS — This is a descriptive epidemiological study using a retrospective population-based registry in Philadelphia, PA, a city with large white, African-American, and Hispanic (Puerto Rican) populations. All hospitals in Philadelphia that admit children were identified. All charts meeting the following criteria were reviewed: 1) newly diagnosed type 1 diabetes, 2) children 0–14 years of age, 3) children residing in Philadelphia at the time of diagnosis, and 4) those diagnosed from 1 January 1990 to 31 December 1994. Standard type 1 diabetes registry data were abstracted from the charts. Ascertainment of the completeness of the hospital registry was validated by data from the Philadelphia School District. Communicable disease records were reviewed to identify epidemics from 1987 to 1995.

RESULTS — A total of 209 cases were identified, and the combined hospital and school registry was determined to be 96% complete. The overall age-adjusted incidence rate in Philadelphia was 13.3/100,000/year. The highest rate by race continues to be in the Hispanic population (15.5). The incidence in African-American children has increased markedly (12.8), particularly in the 10- to 14-year age-group (22.9). An epidemic of type 1 diabetes occurred from January to June 1993, ~2 years after a measles epidemic in Philadelphia.

CONCLUSIONS — The overall incidence of type 1 diabetes in Philadelphia is similar to other U.S. registries. The incidence in the Hispanic population continues to be among the highest of any U.S. ethnic group. The marked increase in incidence in the African-American population may be due in part to misclassification of cases actually having type 2 diabetes. The 1993 epidemic may have been due to β -cell autoimmunity triggered by the measles virus.

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The epidemiology of type 1 diabetes is being monitored through diabetes registries across the country and throughout the world. Determination of differences in diabetes incidence based on age, sex, and race help identify possible risk factors for the development of type 1 diabetes. A review of the worldwide incidence of type 1 diabetes from 1990 to 1994 demonstrated a >350-fold varia-

tion in incidence among 100 populations (1). The Philadelphia registry is unique in that it includes data from large populations of white, African-American, and Hispanic children of Puerto Rican origin. Philadelphia has a population of 320,151 children aged 0–14 years (2). The city is rich in racial and ethnic diversity: 50% of children are African-American, and 10% of the children are Hispanic. Of the His-

panic children 0–14 years of age, 86% are of Puerto Rican origin (3). The epidemiology of type 1 diabetes in children in Philadelphia has been reported for the years 1985–1989 (4). Those data demonstrated that the highest incidence by racial group was in the Hispanic children (15.2). Data from some other registries have reported a low incidence of type 1 diabetes in Hispanic children, but those children were not of Puerto Rican origin (5,6). The registry from Puerto Rico, however, reported an even higher incidence of diabetes in children than the Hispanic children in Philadelphia (7). The Chicago registry also reported an increased incidence of type 1 diabetes in Hispanic children, of whom 20% are Puerto Rican (8).

Epidemics of type 1 diabetes have been reported in the U.S. (9–11) and worldwide (12–15). Identification and investigation of an epidemic can be the cornerstone in understanding the etiology of a disease (16). We evaluated the epidemiology of type 1 diabetes in children in Philadelphia from 1990 to 1994 for the purpose of determining whether the racial differences in incidence rates demonstrated from 1985 to 1989 continued, whether the incidence of type 1 diabetes increased, and if there had been an epidemic during the years 1990–1994.

RESEARCH DESIGN AND METHODS

All hospitals in Philadelphia that admit children were identified and permission to review records was obtained. In addition, several suburban hospitals were identified to attempt to capture Philadelphia residents who were admitted to outlying hospitals. The study identified seven acute care hospitals in Philadelphia that admitted patients with the study criteria. The subjects were all children 0–14 years of age diagnosed with type 1 diabetes from 1 January 1990 to 31 December 1994. Subjects were identified if they had the diagnosis code of type 1 diabetes or if they were being treated with insulin when they were discharged. Data related to evidence of char-

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—Incidence of type 1 diabetes in children in Philadelphia from 1990 to 1994 according to age and race

	Age (years)			Crude rate	Adjusted rate
	0–4	5–9	10–14		
White					
Cases (n)	24	34	30	88	
Population	48,736	44,577	42,352	135,665	
Rate/100,000/year	9.8	15.3	14.2	13.0	13.1
95% CI	6.16–14.36	10.77–21.54	9.45–19.83	10.17–15.63	10.3–15.7
African-American					
Cases (n)	12	29	57	98	
Population	55,637	48,205	49,843	153,685	
Rate/100,000/year	4.3	12.0	22.9	12.8	12.9
95% CI	2.18–7.19	7.88–17.01	17.25–29.29	10.02–15.10	10.1–15.2
Hispanic					
Cases (n)	6	6	9	21	
Population	9,784	8,769	8,568	27,121	
Rate/100,000/year	12.3	13.7	21.0	15.5	15.4
95% CI(I)	6.13–26.57	6.84–29.65	9.34–39.68	9.59–23.60	9.5–23.5
Total*					
Cases (n)	43	70	96	209	
Population	115,678	102,785	101,688	320,151	
Rate/100,000/year	7.4	13.6	18.9	13.1	13.3
95% CI	5.08–9.64	10.44–17.13	15.09–22.83	11.4–14.9	11.7–15.2

Population data are total population 0–14 years. *Total includes two Asian subjects.

acteristics of type 2 diabetes, such as acanthosis nigricans, were not abstracted. All children resided in Philadelphia at the time of diagnosis. Hispanic subjects were identified by a Hispanic surname as documented by the U.S. Census Bureau (2). The country of origin of the Hispanic cases was ascertained from the children's medical records or physicians. Socioeconomic rating was determined according to ZQ (zip quality) rating (17). These criteria are the same as used by the World Health Organization's multinational study to allow for worldwide registry comparison (18).

Ascertainment of the completeness of the hospital registry was determined by a secondary source, a sample of school children with type 1 diabetes. Nurses from the Philadelphia school district obtained parental consent and completed a questionnaire about their students with diabetes. The Philadelphia school district nurses staff all public, private, and parochial schools. Completeness of ascertainment was calculated through the capture-recapture method (19). Communicable disease records from 1988 to 1995 from the City of Philadelphia Department of

Public Health were reviewed to identify epidemics of viral or bacterial reportable diseases.

Age-adjusted incidence rates were calculated for the sample in general and for each subgroup (age, sex, and race) using the 1990 Philadelphia census data. Age adjustment for the rates was done in 5-year intervals (0–4, 5–9, and 10–14) using the direct method with a standard population. Using the Poisson distribution, 95% CIs were computed and were determined to be significant if the CI did not overlap. The relationship between variables was analyzed using the χ^2 statistic. A χ^2 statistic comparing multiple proportions was utilized to ascertain whether there was a significant difference in the yearly incidence rates during the 5 years of the study. The GLIM statistical package determined which variables significantly predicted the risk of type 1 diabetes. Time-series analysis was used to evaluate the changing pattern of the incidence of the disease. The association of viral infections and risk of type 1 diabetes was analyzed by a cross-correlation procedure.

RESULTS— The hospital review identified 209 cases of newly diagnosed type 1 diabetes in Philadelphia in children 0–14 years of age from 1990 to 1994. Cases included patients from seven Philadelphia hospitals. White children accounted for 42% of the cases, African-American children for 47% of the cases, and Hispanic children for 10% of the cases. All Hispanic subjects were of Puerto Rican origin. School records identified 38 eligible children, of whom 36 (95%) were also found in the hospital registry. The total number of estimated cases with the capture-recapture method was 220 (19). The ascertainment rate was calculated for the hospital registry (95%), the secondary source (17%), and the combined registry of primary and secondary sources (96%).

The overall incidence rate was 13.1/100,000/year and the age-adjusted incidence was 13.3, similar to the 13.4 incidence reported in the 1985–1989 data (4). The ascertainment corrected incidence rate was 13.7/100,000/year. The incidence was similar in males and females; 51% of cases were male. In the Hispanic population, the incidence was higher in males. The highest percentage of

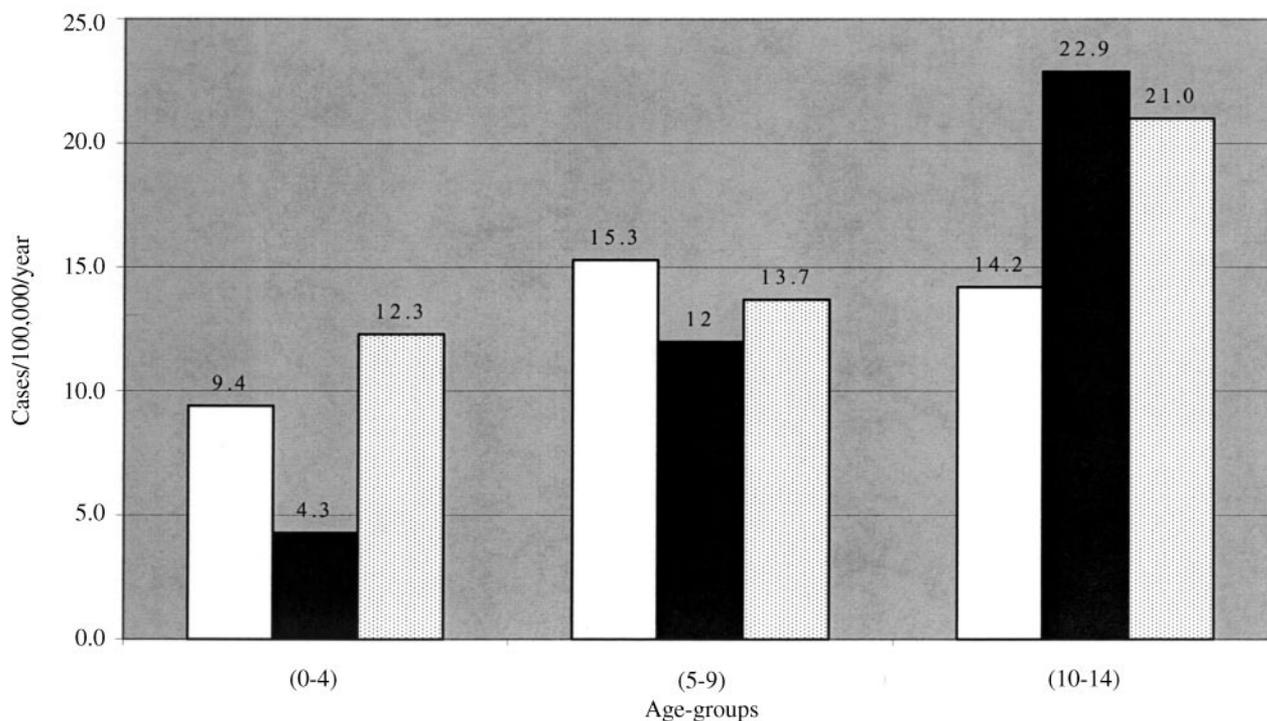


Figure 1—The incidence of type 1 diabetes in children in Philadelphia by age-group and race. □, white subjects; ■, African-American subjects; ▨, Hispanic subjects.

cases was in the 10- to 14-year age-group (46%) followed by 5–9 years (33%) and 0–4 years (21%). The incidence by age-

group was 7.4, 13.6, and 18.9/100,000/year, respectively.

The highest rate by racial group was

in Hispanic children (15.5), as was shown in the previous data (15.0) (4), followed by white children (12.8). The overall in-

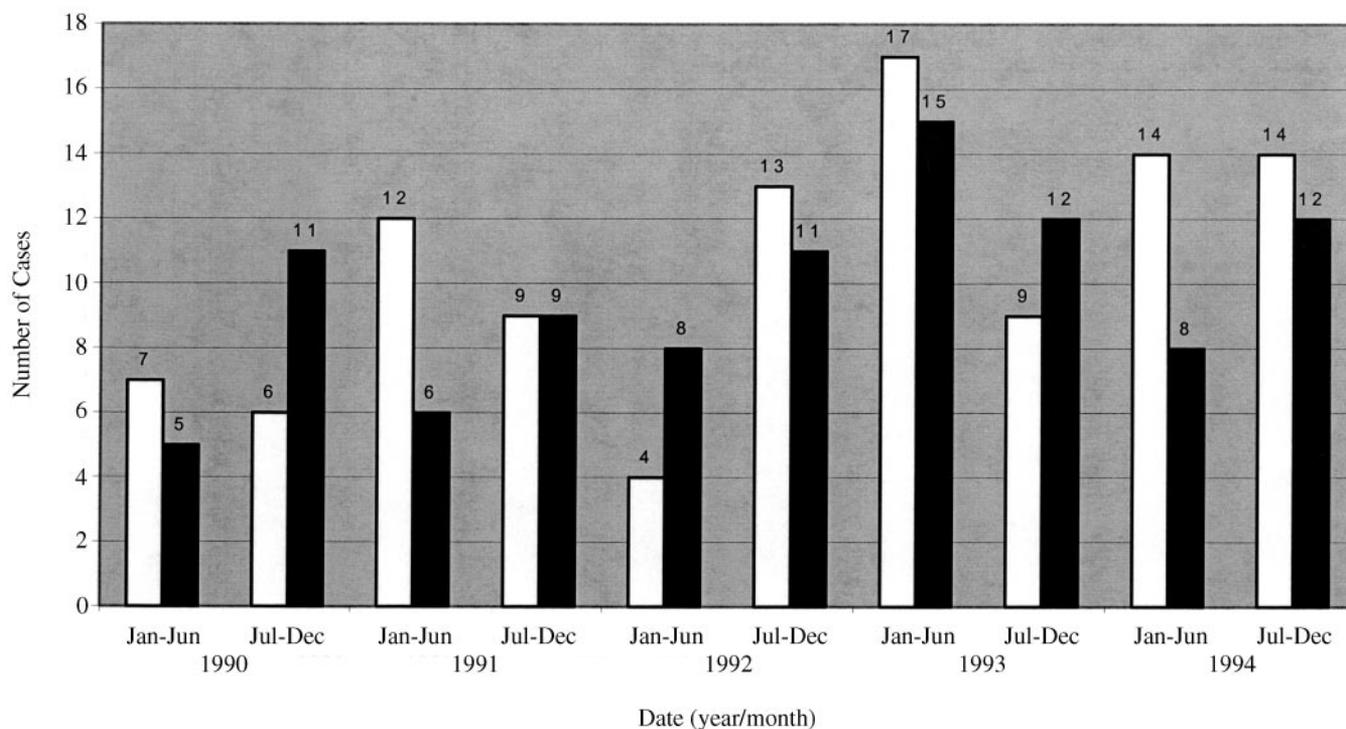


Figure 2—Number of cases of type 1 diabetes in children in Philadelphia from 1990 to 1994 by sex. □, male; ■, female.

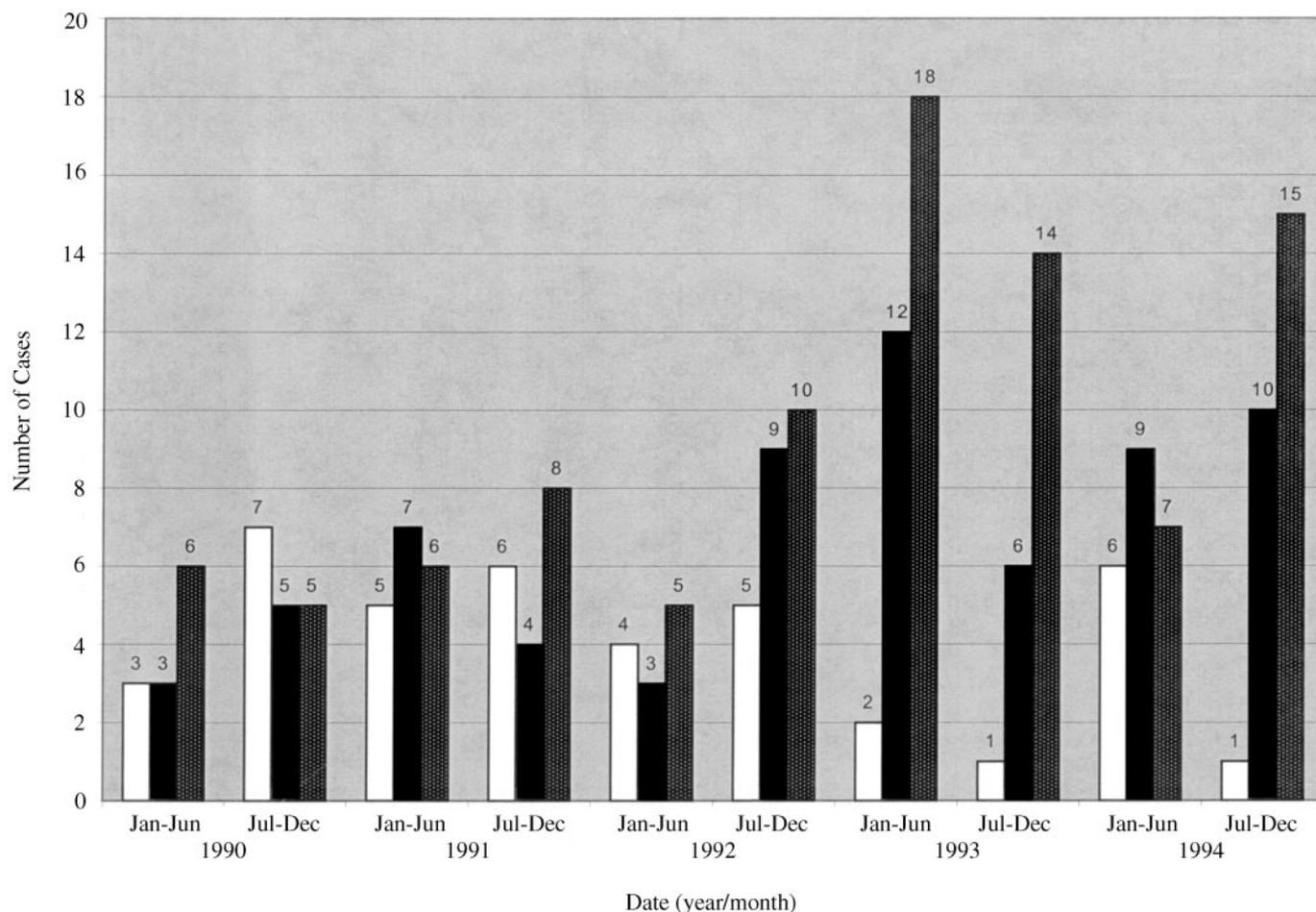


Figure 3—Number of cases of type 1 diabetes in children in Philadelphia from 1990 to 1994 by age-group. □, 0- to 5-year age-group; ■, 5- to 9-year age-group; ▨, 10- to 14-year age-group.

incidence rate in African-American children was 12.8 and was the same for males and females. This is among the highest rate ever reported in African-American children aged 0–14 years. Race itself was not significant in the Poisson regression model. If age is considered as well, however, different racial groups act significantly different according to age-group (Table 1 and Fig. 1). The risk of developing diabetes in children <5 years was 2.4 times greater in white subjects than African-American subjects; in children aged 10–14 the risk was 1.7 times greater in African-American children than white children. The incidence of type 1 diabetes in African-American children aged 10–14 years was 22.9, compared with 19.7 in the previous registry. Age-period cohort showed that age, birth cohort, and the interaction of age and race effects were significant. The second birth cohort (1979–1986) had the highest risk of type 1

diabetes, and the third birth cohort (1987–1994) had the lowest risk. None of the races or age-groups demonstrated a relationship between incidence of type 1 diabetes and socioeconomic status. The season with the highest incidence was spring, but the seasonal variation was minimal and not significant.

When analyzing the incidence by year of onset, the incidence rates were lower when 1990–1992 was compared with 1994–1995, but the difference was not significant. Time-series analysis demonstrated an epidemic of type 1 diabetes from 1 January 1993 to 1 July 1993. There were 32 new cases diagnosed during that time (1.3–2.7 times as many cases as diagnosed in any other 6-month time period). The epidemic occurred in males (20.8), Hispanics (36.9), and children aged 5–9 (23.0) and 10–14 years (35.0) (Figs. 2–4).

Philadelphia communicable disease

records from the Philadelphia Health Department were reviewed, and an ecological analysis was used to evaluate changing patterns of infectious diseases in Philadelphia. Data from 1987 to 1995 revealed a measles epidemic in 1991—1,401 cases were identified compared with 0 in 1988, 68 in 1989, 293 in 1990, and 4 in 1992. During the measles outbreak, 62% of the cases occurred in children <5 years of age and 25% were in children 5–14 years of age. The attack rate in Philadelphia among children <5 years of age was 558/100,000. The children affected with measles included 486 cases of unvaccinated church members (20). In that population, age-specific attack rates were highest among children 1–4 years of age (117 of 122 children, 94%), and 5–14 years of age (298 of 325 children, 91%) (20). The type 1 diabetes epidemic in 1993 affected children in the 5- to 9- and 10- to 14-year age-groups, consistent with the age-

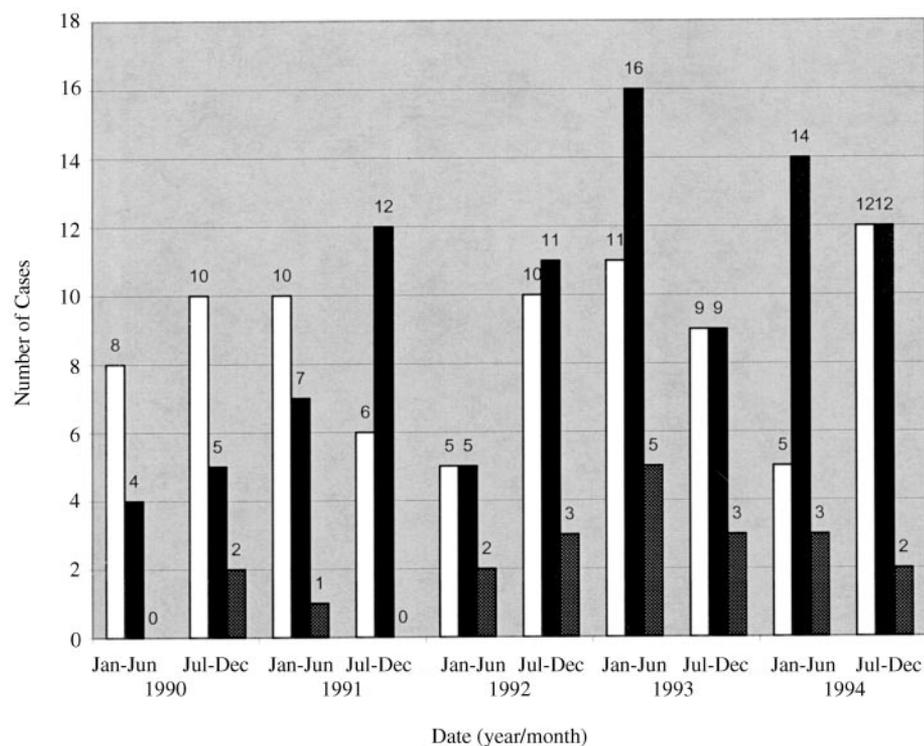


Figure 4—Number of cases of type 1 diabetes in children in Philadelphia from 1990 to 1994 by race. □, white subjects; ■, African-American subjects; ▒, Hispanic subjects.

groups affected by measles 2 years before. It was not possible to determine whether any of the unvaccinated church members developed diabetes or if the incident diabetes cases had antecedent measles. Cross-correlation procedure was used to determine whether attack rates of infectious diseases and type 1 diabetes occurred in the same year, 1 year before, 2 years before, or 3 years before. There appeared to be a relationship between the cases of measles and the type 1 diabetes epidemic in Philadelphia. Cross-correlation analysis revealed that the highest association between the number of cases of measles and type 1 diabetes was at a 2-year lag period ($r = 0.58$).

CONCLUSIONS— The high incidence of type 1 diabetes in Hispanic children in Philadelphia remains among the highest of any racial group in the U.S. The high risk of type 1 diabetes in children of Puerto Rican origin has been replicated in studies in Puerto Rico (incidence 18.0) (7). The higher incidence may be due to a combination of genetic and environmental risk factors. Although a high rate of type 2 diabetes has been reported in the Hispanic population (21), it is unlikely

that the Hispanic cases in Philadelphia have been misclassified with type 1 diabetes. We have demonstrated a high rate of Hashimoto thyroiditis in our population of Hispanic children with diabetes (22), a disorder having a strong association with type 1 diabetes; ~20% of persons with type 1 diabetes have thyroid peroxidase antibodies (23).

The most striking difference between white children and African-American children is the incidence of type 1 diabetes by age-group. In Philadelphia, diabetes in African-American children continues to be rare in the 0- to 4-year age-group. Factors should be explored to determine what possible protective factors could affect this population. The incidence of type 1 diabetes in African-American children aged 10–14 years in Philadelphia has risen so dramatically that the overall incidence of type 1 diabetes is almost equal in the white and African-American population. This has also been demonstrated in the Chicago registry (8) and the Allegheny county registry, where the incidence of type 1 diabetes in African-American children has surpassed the incidence in white children (10). The incidence of type 1 diabetes reported by

several registries from 1975 to 1984 was much lower in African-American children (5,11). It is crucial to consider that the large number of cases of African-American children aged 10–14 years in the Philadelphia registry may be a misclassification of cases of type 2 diabetes. There is an epidemic of type 2 diabetes in children in the U.S., which largely affects African-American children over the age of 10 years. The standard registry criteria for type 1 diabetes is “discharged on insulin.” Many cases of type 2 diabetes require treatment with insulin—particularly at the time of diagnosis—so a number of our cases may have been misclassified. It is unlikely, however, that the increased incidence in African-American children can solely be explained by misclassification. The incidence of type 1 diabetes in African-American children 5–9 years of age has increased from 9.1/100,000/year in the 1985–1989 registry data to 12.0/100,000/year in the 1990–1994 data (4). In this age-group, the increased incidence probably represents a true rise in the incidence of type 1 diabetes in African-American children. We acknowledge that potential under-representation of minority populations by census data can falsely elevate incidence rates. Although there are some data to support a small decline in ascertainment of minority populations compared with the 1980 census that was used for our 1985–1989 diabetes registry, it is unlikely that the change in ascertainment would account for the sharp increase in incidence rates (24).

The most interesting finding of this study is the epidemic of type 1 diabetes in 1993. While diabetes epidemics have been reported in other registries, none have been reported during this time period. Environmental factors that have been associated with variations in the incidence of type 1 diabetes include infant feeding (25,26), viral illnesses (11,27–29), and vaccinations (28,30,31). A difficult issue in determining possible causative agents of type 1 diabetes is the absence of a defined time period between risk factor exposure and onset of disease. In reviewing the communicable disease records of the city of Philadelphia for 1987–1995, there was a measles epidemic from October 1990 to June 1991. Studies have suggested an association between measles and type 1 diabetes (28), while other studies have shown no association (32,33).

Only a weak 2-year lag cross-correlation between the number of cases of diabetes and measles was observed. Nonetheless, in Philadelphia, both the diabetes epidemic and the measles epidemic were evident in the age-groups of 5–9 and 10–14 years. There was also a high measles attack rate in children aged 1–4 years. Given the 2-year time period between the measles and diabetes epidemic, the preschool children affected with measles could have gone on to develop diabetes and contributed to the cohort epidemic of children aged 5–9 years. There are no data on racial and sex distribution of the measles epidemic to compare with the diabetes data. The children in Philadelphia who developed measles included a large group of unvaccinated children who were members of Philadelphia church groups that do not accept vaccinations (20). The Swedish Childhood Diabetes Study showed a significantly higher rate of children who developed diabetes and were not vaccinated against measles. The authors hypothesize that measles vaccine could have a protective effect or that measles infection could be a diabetogenic agent (28).

The Philadelphia registry data remain crucial in the understanding of racial differences in the incidence of type 1 diabetes. The incidence in white and Hispanic children has remained stable since the 1985–1989 data, while the incidence in African-American children has increased. The epidemic of type 1 diabetes in 1993 could provide valuable insight into the etiology of the disease. More studies are needed to investigate the association between measles and type 1 diabetes. Identifying the etiology of a disease is most successful when the investigation occurs during epidemics (16). National reporting of type 1 diabetes should parallel reporting of communicable diseases to facilitate the identification of agents triggering the autoimmune process occurring in type 1 diabetes. Once agents are identified, it may be possible to intervene and ultimately decrease the incidence of type 1 diabetes.

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APPENDIX

Participating Hospitals

Albert Einstein Medical Center, Chestnut Hill Hospital, The Children's Hospital of Philadelphia, Frankford Hospital, Hahnemann University Hospital, Thomas Jefferson University Hospital, and St. Christopher's Hospital for Children.

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