Chapter 3

Prevalence and Incidence of Insulin-Dependent Diabetes

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SUMMARY

The prevalence of insulin-dependent diabetes mellitus (IDDM) in the United States is estimated to be about 120,000 individuals age ≤19 years and about 300,000-500,000 individuals of all ages. There may also be about 0.3% of the U.S. population who have adult-onset IDDM (onset at age ≥30 years) and an unknown number of adults identified as NIDDM (non-insulin-dependent diabetes mellitus) who have slowly progressive IDDM. The incidence of IDDM is about 30,000 new cases each year.

IDDM is one of the most frequent chronic diseases in children in the United States. In the past decade, considerable attention has been given to determining the incidence of IDDM in children, with increasing recognition of the importance of registries. The development of IDDM registries throughout the world has made it possible to present comparably collected data. These data have demonstrated that there is more than a 50-fold geographic variation in the annual incidence of IDDM, ranging from 0.7 per 100,000 in Shanghai, China, to 35.3 per 100,000 in Finland. In the United States, there is considerable racial and ethnic variation in IDDM incidence (3.3 per 100,000 in African Americans in San Diego, CA to 20.6 per 100,000 in whites in Rochester, MN), and about 40% of the incidence rate variation in the United States can be explained by racial composition. For the non-Hispanic white population, males have a slightly higher incidence rate than females, whereas for Hispanics and African Americans the rate is somewhat higher in females. IDDM incidence demonstrates seasonal variation, with lower rates in the summer. Evidence in Europe and in several other countries shows an increasing IDDM incidence over time. In the United States, incidence has been stable over the past several decades, except for rapid rises during certain years and in certain areas that may be suggestive of epidemics.

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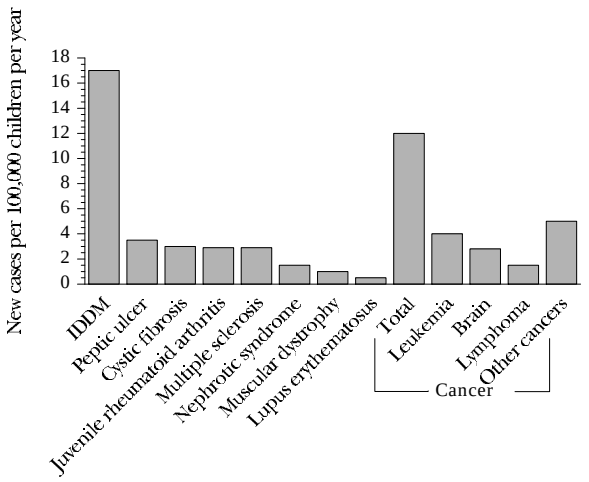
INTRODUCTION

IDDM is one of the most frequent chronic childhood diseases[1]. Figure 3.1 contrasts the incidence of childhood diabetes with that of other chronic diseases in children. The incidence of IDDM is higher than all other chronic diseases of youth. Much has been written about the frequency of childhood AIDS, which is certainly a major health concern. However, the number of children who develop IDDM each year is about 13,000, more than 14 times that seen for cases of childhood AIDS[2]. The economic impact of IDDM is large, with a cost to age 40 years of almost $40,000 per case[3]. The risk of devastating complications remains high. Most certainly IDDM is an expensive and serious condition. Despite its importance, it is only in the past decade that the frequency of IDDM has been intensively investigated through a joint international effort to map the global patterns of this disease.

IDDM REGISTRIES

Reports on the prevalence of IDDM were published primarily before 1980. Most research on IDDM since 1980 has been targeted toward determining the incidence (new cases) of the disease. A major reason for the proliferation of these incidence data is that the question of how frequently IDDM occurs has been recognized as a central and critical issue. In addition, IDDM has characteristics that make it well suited for registration. It is an acute disease, and the onset usually can be identified readily since the symptoms at onset are easily recognized and highly specific to diabetes. Because the disease is severe, cases are brought to medical attention. IDDM is not so severe, however, that mortality occurs before diagnosis and, conse-

Figure 3.1
Incidence of IDDM Compared with Other Chronic Diseases of Children Age <16 Years



Source: Reference 2

Figure 3.2
Location of Registries in the WHO Multinational Project for Childhood Diabetes (DiaMond)

Source: Reference 8

quently, children rarely escape detection in the United States. Cases may be initially misdiagnosed, but a routine blood glucose measurement immediately confirms the diagnosis. The incidence of IDDM is low enough to allow manageable registration. Further, in 1983 a group of international investigators studying IDDM agreed on a common set of criteria for registering cases (Table 3.1)[4], and these were readily applicable in developing and developed countries. Registration systems for IDDM have also incorporated a technology, called capture-recapture, to determine the completeness of registration[5,6]. This entails a formal evaluation of undercount and permits adjustment to produce corrected incidence rates.

The early work on IDDM registries was developed through the Diabetes Epidemiology Research International Group (DERI)[7]. DERI identified broad international variation and the suggestion of temporal variation in incidence. In the early 1990s, the World Health Organization (WHO) began its Multinational Project for Childhood Diabetes (*Diabete Mondiale*, DiaMond)[8]. This project has as its core the establishment of population-based registries with a formal assessment of ascertainment. These registries monitor the global incidence of IDDM, evaluate risk factors for geographic and temporal variation, assess mortality, and evaluate socioeconomic aspects of IDDM. The WHO DiaMond Project also sponsors regional training programs in diabetes epidemiology. Through this project there has been a rapid proliferation of population-based registries. There are now 168 registries in 69 countries monitoring 7.2% of the world's population (Figure 3.2). Fourteen registries monitor the incidence of IDDM in the United States and nine in other countries of North America (Figure 3.3)[9].

Table 3.1
Case Definition for IDDM Registries

Individuals eligible for registration should be:
1. Diagnosed by a physician as diabetic
2. Placed on daily insulin injections before the 15th birthday
3. Resident in the area of registration at the time of the first insulin administration

Source: Reference 4

Figure 3.3
Location of IDDM Registries in North America

Source: Reference 9

Table 3.2
Prevalence Studies of IDDM in the U.S., 1961-92

Ref.	Location	Year of study	Type of study	Age (years)	Prevalence rate (number/1,000 in the age group)
10	Erie County, NY	1961	Hospital records	<16	0.61
11	Rochester, MN	1970	Hospital and physician records	5-18 <15	1.21 0.57
12	Michigan	1972-73	School survey (excluding Detroit)	0-18	1.60
13	National Health Interview Survey	1973	Interview	<16	1.30
14	Pennsylvania	1975-76	School survey	5-17	1.71
15	Allegheny County, PA	1976	Estimate from incidence data	5-17	1.73
16	National Health Interview Survey	1976	Interview	<16	1.60
17	Minnesota	1978	School survey	5-17	1.88
18	Kentucky	1979	School survey	5-17	2.10
18	Rhode Island	1980	Random sample	<15	2.50
18	Colorado	1981	School survey	<15	1.70
18	Utah	1981	Random sample	<15	1.20
19	National Health Interview Survey	1979-81	Interview	<18	1.30
20	North Dakota	1983	Outpatient records	<19	1.30
21-24	National Health Interview Survey	1989-92	Interview	<18	1.20
11,25	Rochester, MN	1970	Hospital and physician records	All ages	1.20
39	National Health Interview Survey	1989	Interview, age <30 years at diabetes diagnosis	≥18	2.1
26	Second National Health and Nutrition Examination Survey	1976-80	Interview, age 30-74 years at diabetes diagnosis	30-74	3.0

Source: References are listed within the table

PREVALENCE OF IDDM IN THE UNITED STATES

Some studies that have estimated the prevalence of IDDM are shown in Table 3.2[10-26,39]. These studies are difficult to interpret and compare because they come from different time periods, are not standardized, and have no evaluation of the degree of ascertainment of cases. Prevalence of IDDM in children ranges from 0.6 per 1,000 to 2.5 per 1,000, with most estimates clustering around 1.7 per 1,000. Using this figure, there are an estimated 123,032 individuals age ≤19 years in the United States who have IDDM (Table 3.3). Thus, IDDM is one of the most prevalent chronic diseases of children. There is little information about the prevalence of IDDM in the total population, but it can be estimated using data from a study in Rochester, MN conducted in 1970[25]. Of all 810 individuals diagnosed with diabetes, 7.9% were classified as having IDDM, and the prevalence of IDDM in the total U.S. population (all ages) was estimated to be 1.2 per 1,000. Based on this rate and the 1990 U.S. population of 252,177,200, the estimated total number of people who have IDDM is 302,613 (Table 3.3).

A study of 2,405 persons age ≥18 years with self-reported physician-diagnosed diabetes in the 1989 National Health Interview Survey (NHIS) found that 124 appeared to have IDDM, based on the criteria of age at diagnosis <30 years, continuous insulin use since di-

Table 3.3
Estimated Prevalence of IDDM in the U.S., 1990

Age (years)	1990 U.S. population	Prevalence rate	No. with IDDM
0-19	72,372,000	1.7/1,000	123,032
≥20	179,805,200		
Total	252,177,200	1.2/1,000	302,613

Source: Based on estimates of IDDM in Table 3.2 (median prevalence of 1.7/1,000 for age ≤19 years and prevalence of 1.2/1,000 for all ages in Rochester, MN in 1970)

agnosis, and absence of obesity[39]. Extrapolating to the U.S. population, an estimate of ~380,000 persons with IDDM age ≥18 years (diagnosed at age <30 years) can be made. This is somewhat higher than the estimate of ~179,581 for age ≥20 years from data in Table 3.3, and results in a prevalence at all ages of ~500,000.

PREVALENCE OF ADULT-ONSET IDDM

IDDM onset is believed to occur predominantly in youth, but it can begin at any age. A study based on the 1976-80 Second National Health and Nutrition Examination Survey (NHANES II) estimated the prevalence of adult-onset IDDM in the United States[26]. The survey included a stratified probability sample of 12,102 subjects age 30-74 years. Cases of IDDM defined by age at diagnosis ≥30 years, continuous or nearly continuous insulin treatment since diagnosis of diabetes, and relative body weight ≤125 were classified as adult-onset IDDM. It was estimated that 7.4% of all diabetic patients diagnosed at age 30-74 years were adult-onset IDDM, which represents 0.3% of the U.S. population in this age group (Table 3.4).

INCIDENCE OF IDDM

UNITED STATES

The incidence of IDDM among children age ≤19 years in Allegheny County, PA is 18.2 per 100,000/year[27]. Applying this rate to the U.S. population, an estimated 13,171 new cases arise each year in persons age ≤19 years (Table 3.5). Data on IDDM incidence in adults in 1945-69 are available from Rochester, MN (Table 3.6)[28]. Applying the overall rate of 9.2 per 100,000 per year to the adult U.S. population, an estimated 16,542 cases of IDDM arise each year in persons age ≥20 years in the United States (Table 3.5). Therefore, about 29,713 Americans develop IDDM each year (Table 3.5).

Table 3.4
Prevalence of IDDM Diagnosed at Age 30-74 Years, U.S., 1976-80

Current age (years)	Proportion of people with diabetes diagnosed at age 30-74 years (%)	Proportion of the U.S. population age 30-74 years (%)
30-49	8.5	0.11
50-64	7.4	0.44
65-74	6.8	0.63
Total, 30-74	7.4	0.30

Source: Reference 26

Table 3.5
Estimated Annual Incidence of IDDM in the U.S.

Age (years)	1990 U.S. population	Incidence rate	No. with IDDM
0-19	72,372,000	18.2/100,000	13,171
≥20	179,805,200	9.2/100,000	16,542
Total	252,177,200		29,713

Data for age 0-19 years are based on studies in Allegheny County, PA in 1985-89; data for age ≥20 years are based on a study in Rochester, MN in 1945-69.

Source: References 27 and 28

With 29,713 new cases each year and 302,613 existing cases, IDDM is a major burden on both the youth and adults of our nation. The 13,171 new cases of IDDM occurring in children each year can be contrasted to the annual incidence of other childhood diseases, including 796 muscular dystrophy cases, 8,829 childhood cancers, and 2,822 leukemia cases[2]. Moreover, if the incidence of IDDM is increasing, as has been suggested, estimates provided here may be low.

INTERNATIONAL VARIATION IN IDDM INCIDENCE

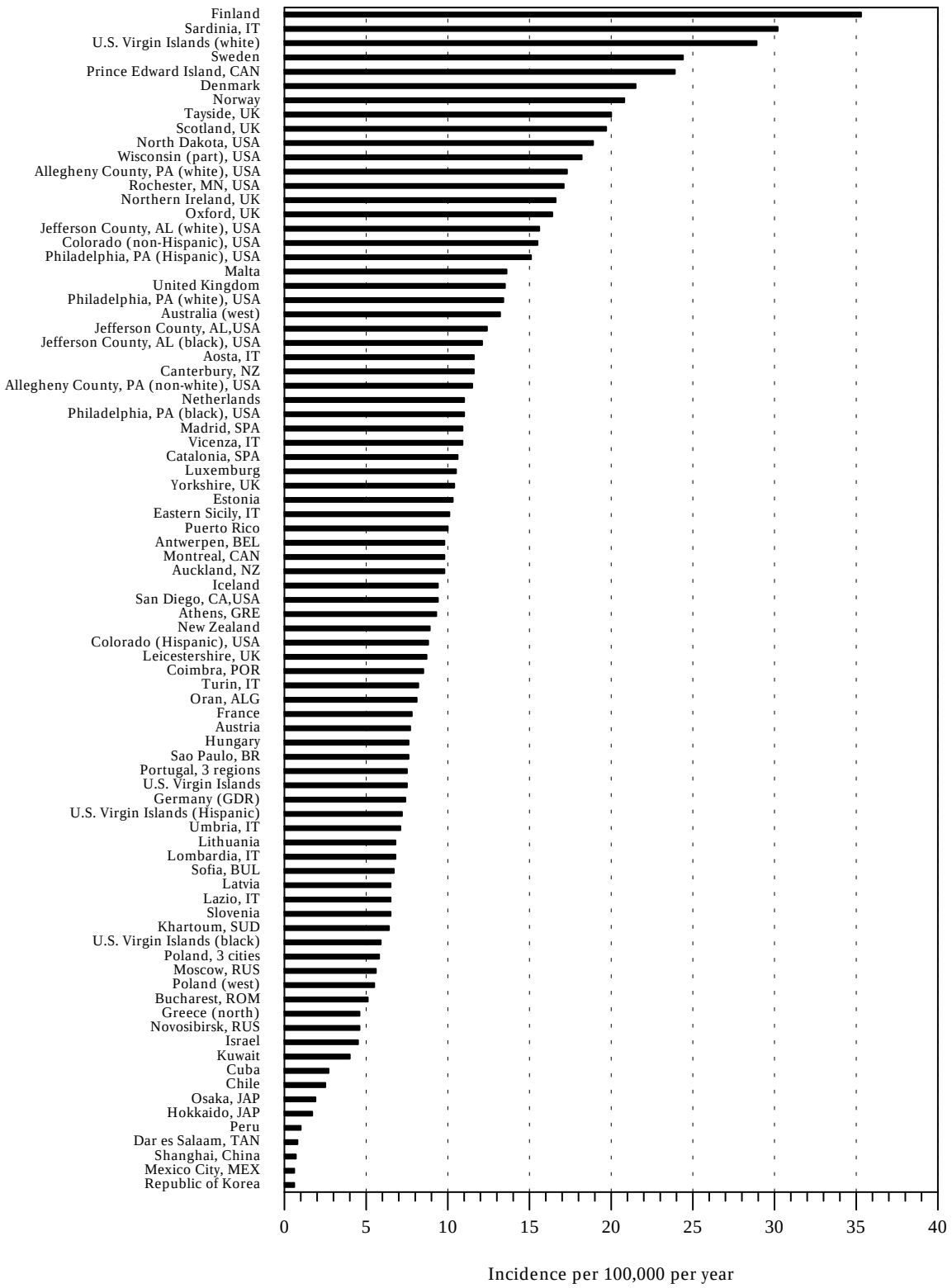
As shown in Figure 3.4, there is remarkable geographic variation in IDDM[9,29]. While the incidence is only 0.7 per 100,000 in Shanghai, China, it is 26 times greater in whites in Allegheny County, PA (18.2 per 100,000), and more than 50 times greater in Finland (35.3 per 100,000). The international variation in IDDM is one of the largest seen for any noncommunicable disease. In Figure 3.5, incidence rates in the United States are contrasted with those in Japan and

Table 3.6
IDDM Incidence at Age ≥20 Years, Rochester, MN, 1945-69

Age (years)	Annual incidence per 100,000 population
20-29	5.2
30-39	4.0
40-49	10.7
50-59	10.5
60-69	9.4
≥70	15.2
Overall (≥20)	9.2

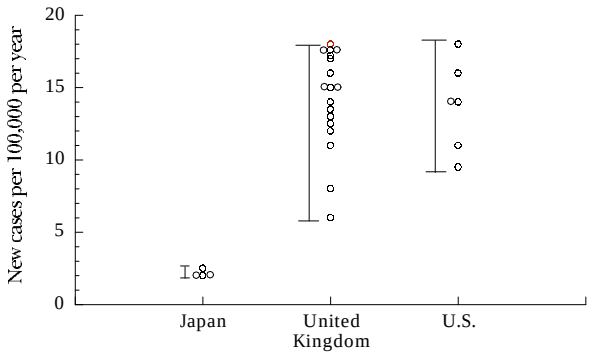
Source: Reference 28

Figure 3.4
Geographic Variation in IDDM Incidence



Source: References 9 and 29

Figure 3.5
Variation in IDDM Incidence Within Countries



Source: Reference 30

the United Kingdom[30]. Within the United States, there is at least a twofold difference in incidence, but about 40% of the variation in incidence rates in the United States can be explained by racial composition of the population[30]. In Montreal, Canada, there are also large differences in IDDM incidence among ethnic groups[31]. In contrast, Japan has a very homogeneous population and shows little variation among studies[30].

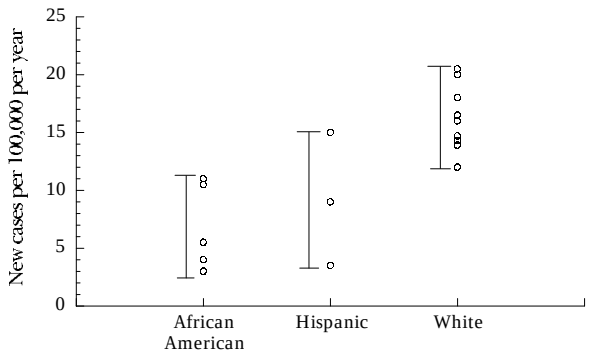
Table 3.7
Age-Adjusted Incidence of IDDM, by Ethnic Group, Age ≤14 Years

	Non-Hispanic			Hispanic
Registry	White	Black	Oriental	
Allegheny County, PA 1965-89	18.1 (17.0-19.2)	10.2 (8.4-12.4)		
Rochester, MN 1970-79	20.6 (13.9-29.5)			
North Dakota 1979-83	20.3 (15.0-17.8)			
Colorado 1978-83	16.4 (15.0-17.8)			9.7 (7.4-12.4)
Jefferson County, AL 1979-83	16.9 (13.4-21.4)	4.4 (2.3-7.5)		
San Diego, CA 1978-80	13.8 (9.8-18.9)	3.3 (0.4-11.9)	6.4 (1.3-18.7)	4.1 (1.3-9.6)
Philadelphia, PA 1985-89	13.3 (11.0-16.1)	11.0 (8.8-13.6)		15.2 (8.8-24.3)
U.S. Virgin Islands 1979-88		5.6 (2.8-8.4)		

Numbers in parentheses are 95% confidence intervals; Hispanic population of Philadelphia, PA is primarily Puerto Rican.

Source: References 7, 32-34

Figure 3.6
Variation in IDDM Incidence Within Racial Groups in the U.S.



Largest rate for Hispanics is for a Puerto Rican group; the other two Hispanic groups are Mexican American

Source: References 7, 32-34

RACIAL AND ETHNIC DIFFERENCES IN IDDM INCIDENCE

Table 3.7 presents age-adjusted IDDM incidence rates for locations in the United States[7,32-34] and shows that there are clear racial and ethnic differences in disease incidence. The highest incidence is among whites and among Hispanic children in the Philadelphia, PA area (where most Hispanics are Puerto Rican), followed by black and Mexican-American children. The incidence rates in Table 3.7 are illustrated in Figure 3.6. Somewhat greater variation of incidence is indicated among Hispanic populations; however, these studies are fewer in number.

IDDM INCIDENCE BY SEX AND AGE

The incidence of IDDM by sex is presented in Tables 3.8 and 3.9. In general, whites have a slight male excess, whereas non-whites have a slight female excess.

Table 3.8
Annual Sex-Race Specific Incidence of IDDM, Age ≤14 Years, Allegheny County, PA, 1965-89

	White	Non-white	Total
Male	18.5 (17.0-20.1)	8.6 (6.3-11.5)	17.0 (15.7-18.4)
Female	17.6 (16.2-19.3)	11.9 (9.2-15.4)	16.7 (15.4-18.2)
Total	18.1 (17.0-19.2)	10.2 (8.4-12.4)	16.9 (15.9-17.9)

Incidence rates are per 100,000 persons age ≤14 years in the sex/race group per year; numbers in parentheses are 95% confidence intervals.

Source: Allegheny County IDDM registry

Table 3.9
Incidence of IDDM, Age <15 Years, U.S., 1965-89

	Study period	Estimate (%) of ascertainment	Incidence per 100,000			M/F Ratio	No. of Cases		
			Male	Female	Total		Male	Female	Total
Puerto Rico	1985-89	?			10.0				
North Dakota	1980-86	?	21.6	16.2	18.9	1.3	120	84	204
Wisconsin (part)	1970-79	<90	20.2	16.2	18.2	1.2	94	72	166
Allegheny County, PA	1970-85	>90							
White			17.0	17.5	17.3	1.0	389	383	772
Non-white			9.7	13.3	11.5	0.7	33	45	78
Rochester, MN	1965-79	100	15.8	18.4	17.1	0.9	18	20	38
Colorado	1978-88	93							
Non-Hispanic			16.4	14.5	15.5	1.1	560	488	1,048
Hispanic			7.1	10.5	8.8	0.7	47	70	117
Jefferson County, AL	1979-85	96	9.9	14.9	12.4	0.7	52	76	128
White			15.1	16.2	15.6	0.9	66	68	134
Black			3.4	10.6	12.1	0.3	10	31	41
San Diego, CA	1978-81	?	9.6	9.1	9.4	1.1	25	23	48
U.S. Virgin Islands	1979-88	92		7.5				27	
Black			6.9	4.8	5.9	1.4	10	7	17
White					28.9				6
Hispanic					7.2				4

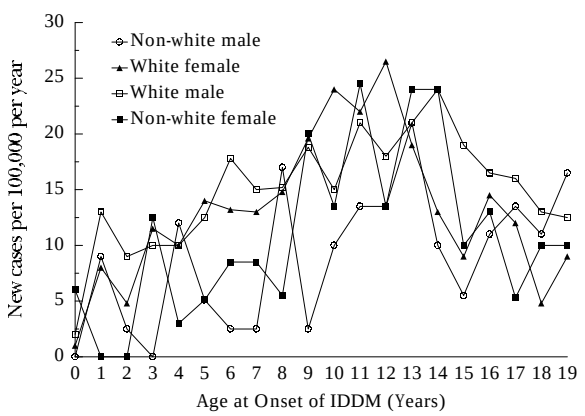
Source: Reference 9

Figure 3.7 presents the characteristic age-at-onset curve with evidence for a pubertal peak. Females have an earlier pubertal peak incidence than males, with the peak occurring about 1 year earlier. This pattern has been seen in almost every registry in the United States and outside the country as well, in Japan[35], for example. Few cases of IDDM develop in the first year of life. There is little information concerning the incidence of IDDM with onset at age >30 years[27].

IDDM INCIDENCE BY SEASON OF THE YEAR

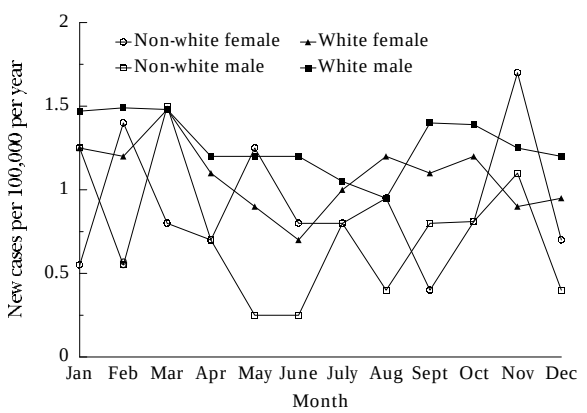
Onset of IDDM occurs in typical seasonal patterns. Data from Allegheny County, PA are presented in Figure 3.8. There appears to be a general decline in cases in the summer. The decline typically is not large but has been seen consistently across registries. Other studies in temperate climates have demonstrated statistically significant bimodal peaks in the late winter and early spring months[9].

Figure 3.7
Incidence of IDDM, by Age at Onset, Allegheny County, PA



Source: Reference 27

Figure 3.8
Incidence of IDDM, by Month of the Year, Allegheny County, PA



Source: Reference 15

TEMPORAL TRENDS IN IDDM INCIDENCE

Table 3.10 presents an overview of selected studies on temporal trends in IDDM[36]. In Europe there has been an increase in the incidence of IDDM. In the United States, there is no evidence for changing incidence of IDDM during 1966-86 (Figure 3.9). Data from Allegheny County, PA show a markedly increased incidence of IDDM among males but not females during 1985-89 compared to previous periods (Figure 3.10)[27].

In addition to the experience in males in Allegheny County, PA during 1985-89, there have been spiking patterns of IDDM incidence over time observed elsewhere, which may be suggestive of epidemics. In the U.S. Virgin Islands (Figure 3.11), there was a dramatic rise in incidence in the mid-1980s[34]. Other centers in the Caribbean, including Barbados, also demonstrated this epidemic pattern[37]. There was a marked rise in IDDM incidence in Birmingham, AL in 1983 (Figure 3.12), which coincided with a coxsackievirus infection in the area[38]. Incidence data worldwide suggest that there was an apparent pandemic of IDDM, which occurred in the United States and in a large proportion of countries across the world[27,36]. Thus, there is evidence that IDDM is increasing globally (Table 3.10), and epidemics of IDDM may account for the overall increase.

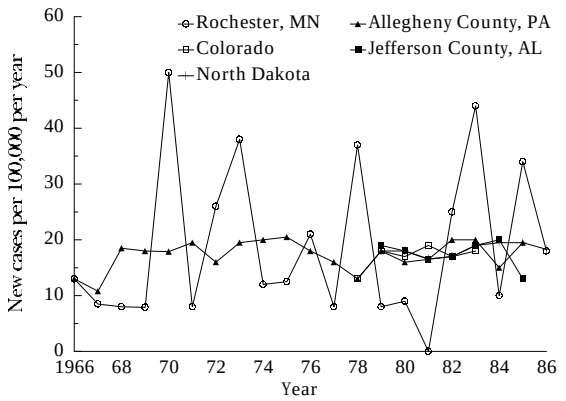
Table 3.10
Temporal Variation in IDDM Incidence

Registry	Best model	Annual change (%)
North America		
Allegheny County, PA		
White	No trend	
Black	No trend	
Rochester, MN	No trend	
Jefferson County, AL		
White	No trend	
Black	No trend	
Colorado		
Non-Hispanic	No trend	
Hispanic	No trend	
North Dakota	No trend	
Montreal, Canada	Common nonlinear variation	
Prince Edward Island, Canada	No trend	
Europe		
Finland	Common nonlinear variation	+3.4
Vasterbotten, Sweden	Different nonlinear variation in age groups 0-4, 5-9, and 10-14 years	
Sweden	Common linear trend	+3.7
Norway	Common linear trend	+2.8
United Kingdom	Different linear trend	
	0-4 years	+11.5
	5-9 years	+12.2
	10-14 years	+2.6
Scotland	No trend	
Wielkopolska, Poland	Common linear trend	+5.6
Austria	Common linear trend	+5.1
Asia and Western Pacific		
Hokkaido, Japan	Common linear trend	+6.3
Auckland, New Zealand		
White	Common linear trend	+10.1
Maori and Polynesian	No trend	

Best-fitting models for temporal variation in age- and sex-adjusted incidence of IDDM for selected registries participating in Diabetes Epidemiology Research International Group.

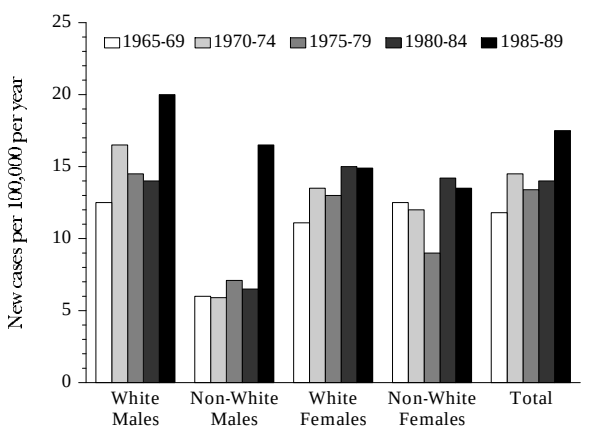
Source: Reference 36

Figure 3.9
Temporal Trends in IDDM Incidence in U.S. Registries



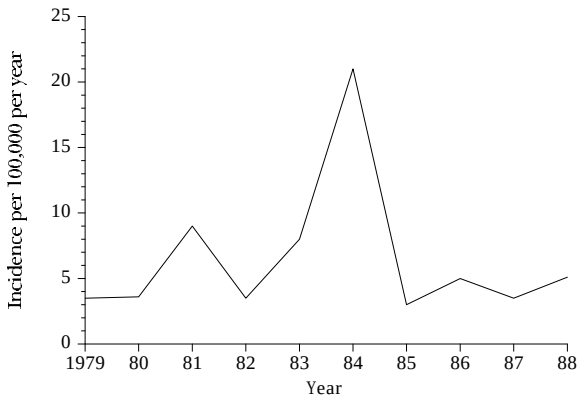
Source: Reference 36

Figure 3.10
Incidence of IDDM, by Race, Sex, and Year, Allegheny County, PA



Source: Reference 27

Figure 3.11
Incidence of IDDM in Black Children Age ≤19 Years, U.S. Virgin Islands, 1979-88

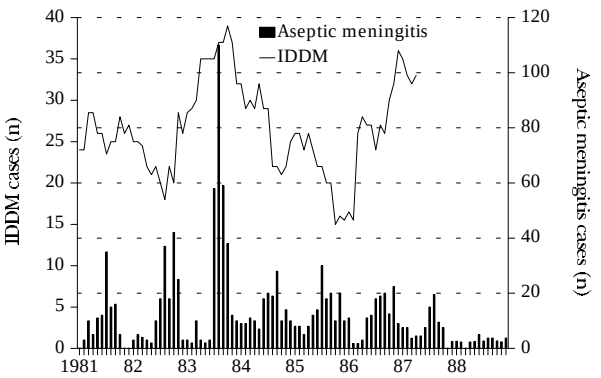


Source: Reference 34

CONCLUSIONS

Little information is available on the prevalence of IDDM. Because policymakers, clinicians, and public health officials require meaningful data to develop actions aimed at reducing the impact of IDDM, there is a need for accurate and current information on prevalence. Regular monitoring of the frequency of IDDM is the best means to achieve these data. This capability, though, does not yet exist. There has been a rapid increase in our knowledge concerning the geographic variation of IDDM. Investigations of the causes of geographic variation may provide important insight into the epidemiology and etiology of IDDM. Evidence of a rise in incidence in certain countries, as well as the suggestion of epidemics, have left unanswered questions about etiologic factors. An effective national monitoring system for IDDM would enable the search for environmental factors related to the etiology of IDDM and provide necessary information for public health planning.

Figure 3.12
Incident IDDM Cases Age <20 Years, Allegheny County, PA, and Aseptic Meningitis Cases, All Ages, Jefferson County, AL



IDDM cases are plotted as a 12-month moving sum; coxsackievirus is a common agent in aseptic meningitis and is hypothesized to be an etiologic agent in IDDM.

Source: Reference 38

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