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Increasing incidence of diabetes mellitus in Norwegian children 0–14 years of age 1973–1982

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Summary. A retrospective technique was used to register all newly diagnosed cases of diabetes mellitus in Norwegian children 0–14 years of age during the ten-year period 1973–1982. A total of 1,914 newly diagnosed cases were detected, from an average population of 932,037 children. The degree of ascertainment was near to 99%. The male incidence exceeded the female incidence by 12% ($p < 0.02$). The mean yearly incidence for the ten-year period was 20.5 per 100,000. Comparing the two five-year periods 1973–1977 and 1978–1982, the mean yearly incidence increased from 18.5 to 22.7 per 100,000 ($p < 0.0001$). There was a marked geographic variation with the highest incidence in the south-east and lower incidence in the northern part of the country. However, in the northern part of the country, there was a remarkable increase of the annual incidence from the first to the second five-year period (12.9 vs 19.3 per 100,000). The highest numbers of new cases were detected in the months of January and October, and the lowest numbers in May and July. The seasonal pattern was significantly different from a uniform distribution of new cases throughout the year ($p < 0.001$). The age-specific incidence increased towards a peak at 12 years for both sexes. In conclusion, Norway has a high and apparently increasing incidence of childhood diabetes. The geographic variation and secular trend present challenging clues for a search of etio-pathogenic factors.

Key words: Diabetes mellitus, childhood, incidence, geographic pattern, seasonal pattern, secular trend.

The interest in the epidemiology of Type 1 (insulin-dependent) diabetes has been increasing through the past decade, with data being published from population-based diabetes registries in various parts of the world. Major geographic variations in the incidence of Type 1 diabetes have thus been recognised [1].

The Nordic countries represent a typical high-incidence area [2–5] with incidence figures of childhood diabetes several times higher than observed in some other European countries, e.g. France [6] and Japan [7].

The first nationwide study of childhood diabetes in Norway [2] showed a mean yearly incidence of 17.6 per 100,000 children in the age group 0–14 years during 1973–1977. That rate was considerable higher than those observed in earlier studies in parts of the country [8–10] but comparable to the incidence in Sweden [11] and Finland [12] in the 1970's. Our study also demonstrated major geographic variations within the country, considerable seasonal variation and variation by sex and age.

In the present work, the study period was extended from five to ten years to get more reliable epidemiological data. In particular, we were interested in analysing the time trend of diabetes incidence in Norwegian children after 1977 and, furthermore, re-examine the previously noted regional variations of incidence.

Subjects and methods

Population and geographic data

In the study period 1973–1982, Norway had approximately four million inhabitants. About 23% of the population were in the age group 0–14 years, the yearly mean for the study period being 932,037 children below 15 years. Norway has a considerable south-north extension, reaching from the 57th to the 71th latitude. The mainland of the country covers about 324,000 km^2 and is comprised of 19 counties. There are about 20,000 Lapps and a smaller number of people of Finnish origin, who live mainly in the three northernmost counties. In 1982, there were about 90,000 temporary residents in the country, mostly Europeans.

Collection of data

The data have been collected separately for the two five-year periods 1973–1977 and 1978–1982 but with identical methods. A questionnaire was sent to all paediatric and medical hospital departments in Norway in 1978 and in 1984, respectively. In 1978, all 18 paediatric and 69 out of 72 medical departments responded. In 1984, the number of paediatric departments was increased to 19 and all of them responded. The number of medical departments contacted in 1984 was 63 compared to 72 departments in 1978, the reason being increased centralisation in the treatment of childhood diabetes and changes in the status of some medical departments. Two of the responding medical departments could not produce data for the years 1978–79 and 1980–82, respectively. The hospitals reported the following data for

Table 1. Number of cases ascertained from hospital records (source A) and insurance registry (source B) by five-year study period

			1973–1977 Hospital record			1978–1982 Hospital record		
Insurance register			+	−	Total	+	−	Total
		+	736[a]	38[b]	774	786[a]	103[b]	889
		−	107[c]	x	107+x	144[c]	x	144+x
		Total	843	38+x	881+x	930	103+x	1033+x
			n=736+38+107+x			n=786+103+144+x		

n=number of children studied; [a] new cases with a hospital record and an insurance record; [b] new cases with an insurance record but without a hospital record; [c] new cases with a hospital record but without an insurance record; x unknown number of cases not registered in any source

Table 2. The mean annual incidence of Type 1 (insulin-dependent) diabetes mellitus in children 0–14 years of age in Norway 1973–1982

County area	Number of children 0–14 years of age (Mean of years 1973–1982)	Number of new cases with diabetes 1973–1982	Mean annual incidence (n/100,000) (range)
1. Østfold	51,676	121	23.4 (9.8–33.0)
2. Akershus	89,098	182	20.4 (10.9–28.2)
3. Oslo	72,936	155	21.3 (12.0–28.9)
4. Hedmark	38,924	69	17.7 (7.4–30.0)
5. Oppland	39,698	92	23.1 (12.2–32.3)
6. Buskerud	46,237	122	26.4 (15.2–35.3)
7. Vestfold	41,622	97	23.3 (11.6–35.4)
8. Telemark	35,323	92	26.0 (11.8–36.3)
9. Aust-Agder	20,805	57	27.4 (9.5–46.8)
10. Vest-Agder	33,499	77	23.0 (11.6–35.4)
11. Rogaland	76,319	141	18.5 (7.9–26.1)
12. Hordaland	95,018	180	18.9 (13.3–27.3)
14. Sogn og Fjord	25,138	58	23.1 (15.6–32.7)
15. Møre og Roms	57,729	106	18.4 (12.8–26.5)
16. Sør-Trøndelag	56,949	105	18.4 (11.9–25.7)
17. Nord-Trøndelag	31,068	58	18.7 (6.3–32.2)
18. Nordland	60,246	110	18.3 (11.0–27.7)
19. Troms	37,772	68	18.0 (5.1–30.7)
20. Finnmark	21,970	24	10.9 (4.3–31.0)
Total	932,037	1914	20.5

Table 3. Cumulative incidence rates and 95% confidence limits at 15 years of age by sex and five-year period (per 1,000)

Sex	1973–1977	1978–1982
Boys	2.94 (2.79, 3.09)	3.46 (3.28, 3.64)
Girls	2.59 (2.46, 2.72)	3.16 (3.00, 3.32)

all new cases of diabetes mellitus in the age group 0–14 years during the years 1973–1977 and 1978–1982, respectively: name, sex, date of birth, personal identification code, place of residence at the time of admission, and date of hospital admission. The onset of diabetes was defined as the day of admission in hospital.

All persons with diabetes mellitus who receive a basic allowance are registered by the National Insurance Institution. From the Insurance Register the following data was reported: place of living, sex, date of birth, personal identification code, name and date of entry in the register. Date of entry into the register are identical to the date of diagnosis in the medical certificate.

A child was thus registered as a newly diagnosed case of diabetes if he or she was treated with insulin for the first time in hospital within the study period and/or reported from the insurance register with a diagnosis of diabetes mellitus and an entry date within the study period.

Validation of ascertainment

The degree of ascertainment was established by comparing the data from the hospital departments and the National Insurance Institution. The ascertainment was calculated separately for the two five-year study periods.

Study period 1 (1973–1977): The total number of new cases was 881, of which 38 were primarily registered only by the insurance registry and not reported from any hospital. In these cases, the diagnosis of diabetes mellitus was ascertained partly by a second letter to the hospital and partly by information from the local health insurance offices. Not found in the insurance registry were 107 children, probably because of missing or delayed report from the local insurance office.

Study period 2 (1978–1982): The total number of new cases was 1,033; of which 103 were only registered in the insurance register. Based on the experience that the data of the insurance register is reliable, the diagnosis and the time of diagnosis were not ascertained by further contact with the hospitals, although 144 cases reported from hospitals were not found in the insurance register.

Table 1 contains the basic data for estimation on completeness of ascertainment. The method employed was as described by Bishop, Fienberg and Holland [13], and the completeness of ascertainment for both sources was calculated in the following steps and separately for study period 1 and 2:

Completeness of source A = $C_A = (a+c)/N$
Completeness of source B = $C_A = (a+b)/N$
$C_A = a/(a+b)$ $C_B = a/(a+c)$
Probability of escaping both methods (sources) = $X/N = (1-C_A)(1-C_B)$
Combined completeness of ascertainment source A and B = C_{AB} (%) = $(1-x/N) \times 100$
Completeness of ascertainment are presented as percentages with 95% confidence limits.

The combined completeness of ascertainment from both methods was 99.4% (98.9, 99.9) in study period 1 and 98.2% (97.4, 99.0) in study period 2. The ascertainment probability for hospital records decreased from 95.1% in study period 1 to 88.4% in study period 2. This decreased probability could be due to the increased number of non-responding departments from three to six, and the fact that two departments could only produce data for two out of five years in study period 2.

Therefore, in future studies, greater efforts should be made to obtain data from computer-based patient-administrative systems.

It is our experience that "missing cases" in hospital registries are due to insufficiencies in hospital diagnosis registries and not a result of a practice implicating that children with newly detected diabetes are treated outside hospitals. Further, 1,522 out of 1,773 hospital cases receive their basic allowance. We, therefore, feel justified to state that the method of ascertaining new cases of diabetes mellitus employed in this study are well fitted for incidence studies in our country.

Statistical analysis

Age adjusted incidence rates per study period and per county in the total material and incidence rates per study period in the region "Northern Norway" were separately analysed by the Mantel-Haenzel test [14]. The significance of differences in cumulative incidence per study period was tested by an ordinary chi-square test. Sex difference and seasonal variations were analysed by chi-square tests on unadjusted incidence rates.

Table 4. Annual incidence rates per age group, five-year period and sex 1973-1982

Age group (years)	1973-1977						1978-1982					
	Boys			Girls			Boys			Girls		
	Mean population	Number of cases	Mean yearly incidence per 100,000	Mean population	Number of cases	Mean yearly incidence per 100,000	Mean population	Number of cases	Mean yearly incidence per 100,000	Mean population	Number of cases	Mean yearly incidence per 100,000
0- 4	159,825	100	12.5	152,424	77	10.1	136,207	81	11.9	130,001	85	13.1
5- 9	169,058	180	21.3	160,174	150	18.7	160,915	204	25.4	153,653	162	21.1
10-14	159,892	198	24.8	151,788	176	23.2	169,804	277	32.6	160,833	224	27.9
0-14	488,775	478	19.6	464,386	403	17.4	466,926	562	24.1	444,487	471	21.2

Results

A total of 1,914 children were registered as new cases of diabetes mellitus during the ten-year study period, 881 in the period 1973-1977 and 1,033 in the period 1978-1982, of which 1,037 cases were boys and 877 cases were girls. Table 2 gives the mean yearly incidence and ranges for all 19 counties in Norway. The mean yearly incidence in the entire country for the ten-year period was 21.7 for boys, 19.3 for girls and 20.5 per 100,000 for both sexes. The male incidence exceeded the female incidence by 12% ($p<0.02$).

As shown in Figure 1, there was a moderate year-to-year variation within the ten-year period (range 15.4-23.8). The mean yearly incidence in the two five-year periods 1973-1977 and 1978-1982 was 18.5 and 22.7 per 100,000, respectively, and this increase in incidence rates from period 1 to period 2 was statistically significant ($p<0.0001$).

Table 3 demonstrates the cumulative incidence rates at 15 years of age in each five-year period, and the cumulative incidence during the second period was significantly higher than in the first period ($p<0.05$).

Table 4 shows the annual incidence separately per age group, sex and five-year period. The incidence tended to increase from the first to the second five-year period in all groups, except for youngest boys. The incidence increased from the first to the second five-year period in 16 out of 19 counties and decreased in three counties.

There seems to have been a marked increase in incidence from the first to the second five-year period in the three northern-most counties ("Northern Norway", county areas no. 18,19 and 20 in Fig. 2). The mean yearly incidence for these three counties separately changed from 12.9 per 100,000 in 1973-1977 to 19.3 in 1978-1982 ($p<0.01$).

The mean yearly incidence during the total ten-year period was 16.8 per 100,000 in Northern Norway separately (three counties) vs a mean of 21.1 per 100,000 in the rest of the country. This difference between Northern Norway and the rest of the country was statistically significant ($p<0.01$).

The overall incidence figures for the ten-year period show a marked geographic variation (Fig. 2). The highest incidence was found in the densely populated south-eastern region. In the western and central part of the country, the incidence was medium high; whereas, the northern part of the country had a lower incidence of diabetes mellitus.

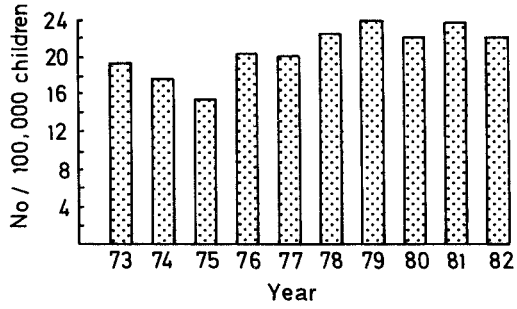

Fig. 1. Annual incidence of diabetes mellitus in Norwegian children (⊡) 0-14 years of age 1973-1982

The age-specific incidence rates in the total material and rates by sex are given in Figure 3. The incidence rates are gradually increasing with age towards a peak at 12 years for both sexes.

As shown in Figure 4, the highest numbers of new cases were registered in January and October and the lowest numbers in May and July. The seasonal pattern in the total material is significantly different from a uniform distribution of new cases ($p<0.001$). The mean number of new cases in the winter months, December through February, was significantly different from the yearly mean ($p<0.05$). The seasonal variation was less pronounced in the youngest age group, 0-4 years of age. When the variation in the monthly number of new cases was tested for each age group separately, a significant seasonal variation could only be demonstrated in the age groups 5-9 years ($p<0.01$) and 10-14 years ($p<0.01$).

Discussion

Several studies have documented a high incidence of diabetes mellitus in children in the Nordic countries [2-5], the incidence being higher than in many other parts of the world [6, 7, 16]. The incidence of diabetes mellitus in the age group 0-14 years, as here reported, is

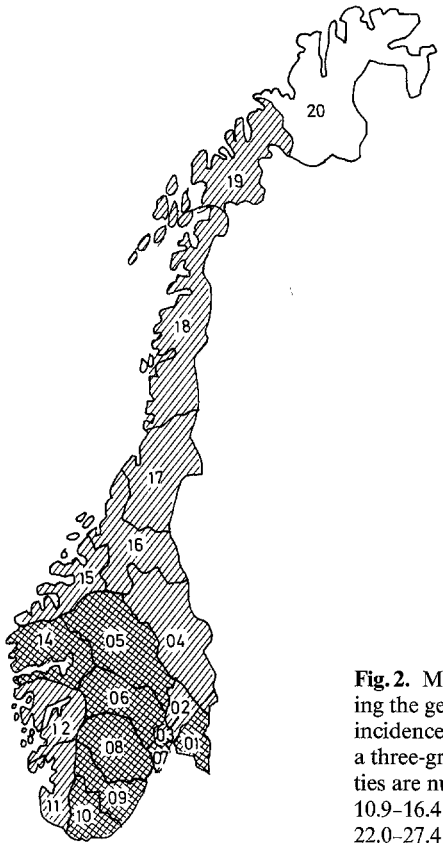

Fig. 2. Map of Norway indicating the geographic variation in incidence (no./100,000/year) in a three-graded scale. The counties are numbered as in Table 1. 10.9–16.4 □; 16.5–21.9 ▨; 22.0–27.4 ▩

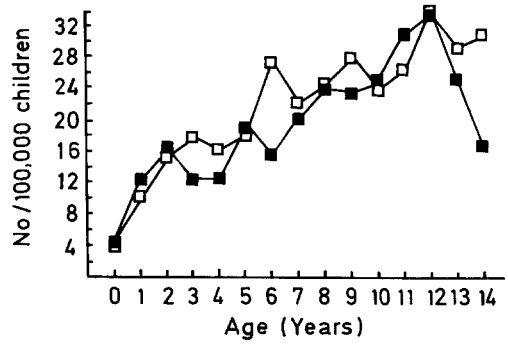

Fig. 3. Age-specific incidence of diabetes mellitus by sex. Boys □—□; girls ■—■

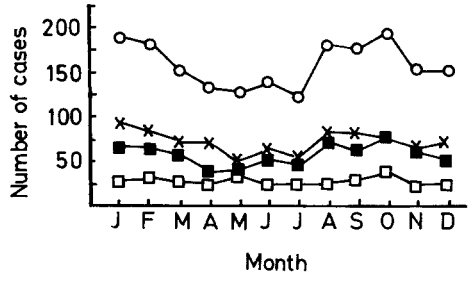

Fig. 4. Seasonal variation in the onset of diabetes mellitus in 1914 Norwegian children 0–14 years by age group. 0–4 years □—□; 5–9 years ■—■; 10–14 years ×—×; 0–14 years ○—○

similar to that reported from Sweden for the same time period [23]. The methods employed in these studies were similar, with a comparable degree of ascertainment. In the Nordic countries, a large majority of diabetic children undoubtedly has Type 1 diabetes, although the prevalence of maturity onset diabetes of the young (MODY) is unknown.

World-wide studies of the incidence of childhood diabetes have uncovered major regional differences [1]. Some of these variations may be attributed to different genetic backgrounds (e.g. Japan vs Europe) but there are clearly geographic differences which cannot readily be understood on a genetic basis. The present work also demonstrates regional differences of incidence on a national basis, with at least two-fold higher incidence in the south-east than in Northern Norway. Norway is ethnically homogeneous, except for the northernmost counties, where the impact of the Lapps and the Finnish people is of importance. The incidence of Type 1 diabetes in Lapps may be low, but this is counterbalanced by a well documented high incidence in people of Finnish ancestry [3]. Thus, there are within Norway geographic differences in the incidence of childhood diabetes which cannot be explained by ethnic and genetic factors.

Reports from various parts of the Western World have been contradictory on the question of whether the incidence of Type 1 diabetes is increasing or not. Studies from Finland [3], Sweden [4], Michigan, USA [15], Great Britain [17, 18] and Denmark [19] have reported increasing incidence; whereas, authors from Pennsylvania, USA [20] and Canada [21] could not confirm such a trend.

In the present study, we have found an incidence of diabetes mellitus in children which is considerably higher than found in earlier studies by other authors from Norway [8–10]. Admittedly, different methods were employed in these studies, and the degree of ascertainment in the earlier studies are unknown. However, the differences in incidence reported are too large to be reasonably accounted for by improvement in record keeping, or changing numbers of children in the population and shifting age distribution. The moderate increase of incidence during the ten-year period 1973–1982, therefore, appears to be part of a long-term trend in Norway, and it is difficult to escape the conclusion that the incidence of childhood diabetes in this country is more than doubled in the course of the last 25–30 years. Such a rapid change of morbidity cannot be explained by genetic factors and clearly indicates the operation of environmental factors as determinants of risk for developing Type 1 diabetes in susceptible individuals. Since no single environmental factor responsible for changes in the incidence of Type 1 diabetes has ever been identified, one has to consider a possible role of infectious diseases, toxic substances, nutritional changes and psychosocial factors.

In a recent compilation of epidemiological data from several countries world-wide [1], a high incidence of childhood diabetes was associated with low average yearly temperature. Data from Western Europe apparently support such a trend, with decreasing incidence

from north-east towards south-west [22]. It is, therefore, remarkable that Norway, with its considerable north-south extension, clearly has its lowest incidence of childhood diabetes north of the polar circle. A similar north-south gradient was observed within Finland [3]; whereas such a pattern was not found in Sweden [4]. The present study has demonstrated not only major differences of incidence within the country but also a apparently rapidly increasing incidence in the low-incidence region Northern Norway. It is noteworthy that an increasing incidence appeared at a later date in Northern Norway than in the southern parts of the country. The seasonal variation in the incidence of Type 1 diabetes has again been documented in the present work. Since the pathological process leading to Type 1 diabetes may start years before the clinical onset, the seasonal variation probably reflects the operation of triggering rather than aetiological factors. As observed previously [11], there was a more even distribution of new cases by month for the youngest children; but, because of the relatively small number of patients in this age group, this observation should be interpreted with caution.

In conclusion, this ten-year retrospective study has shown a high and increasing incidence of diabetes mellitus in Norwegian children. Taken together with previously published data from this country, the present work indicates a two-fold increase in incidence throughout the three decades from 1953 to 1982. The epidemiological pattern in Norway is otherwise typical of the Nordic countries, with a male dominance, a peak incidence in the pre-pubertal age in both sexes and a seasonal variation in the incidence in the age groups 5–9 and 10–14 years.

The main results of the present study, the marked geographical variation in the incidence and the time trend observed, give a challenging clue for further epidemiological studies in Norway, with special emphasis on changes in living conditions, panorama of viral infections, immunisation practice and breast-feeding habits.

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