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Immunity against diphtheria in adults in Poland

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SUMMARY

The diphtheria immunity status was determined with the passive haemagglutination technique in 503 sera of 10–90-year-old persons from Warsaw and Olsztyn Provinces. Donors of sera were students, teachers, pregnant women, employees of industry and medical service. The immunity was highest (90% of titers 0·1 IU/ml or higher) in persons below 20 years of age and in persons above 60 years of age (55%). Between these two groups, gaps in immunity exist, the proportion of those immune varying from 36–50% in the 20- 60-year-old groups.

Since a large pool of susceptible persons creates an epidemic potential it was suggested that the adult type of tetanus-diphtheria toxoid (Td) should be introduced into the routine immunization schedule for high risk groups. These groups might include professional or age groups who are vulnerable to reintroduction of virulent *Corynebacterium diphtheriae* such as kindergarten and creches personnel, teachers, students, military service personnel and persons travelling to developing countries.

INTRODUCTION

The WHO Regional Committee for Europe at its 1984 Annual Meeting adopted as one of the targets for achieving Health for All by the year 2000, the elimination of indigenous measles, poliomyelitis, neonatal tetanus, congenital rubella and diphtheria from the Region by the year 2000.

A conference of European countries which took place in December 1984 in Karlovy Vary, Czechoslovakia, agreed in respect of diphtheria on the following immunization and morbidity targets: by 1990 all countries should fully protect by immunization at least 95% of children before their second birthday and subsequently maintain immunity, and by the same year diphtheria should be eliminated from the European Region (1).

Many countries have already fulfilled or are near to fulfilling these requirements. Not a single case of diphtheria was reported in 12 countries for at least three consecutive years in 1987, and in some the disease has not been reported for over 10 years (Table 1).

In Poland, mass immunization against diphtheria was introduced in 1960 and

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Table 1. *European countries reporting to the WHO the zero incidence for diphtheria over three years or more consecutive years during the period 1974–87*

Country	No. of years with zero incidence	Period with zero incidence
Finland, Iceland, Malta	14	1974–87
Ireland, San Marino	13	1974–86
Norway	11	1977–87
Bulgaria, Yugoslavia	7	1981–7
Luxembourg	6	1982–7
Greece	5	1983–7
Switzerland	4	1984–7
Spain	3	1985–7

According to EPI 1988 (2)

resulted in the virtual elimination of diphtheria as a public health problem (3–5). The immunization coverage with three primary doses of DPT in infants exceeds 95% and a similar proportion of children receive a fourth dose of the vaccine at the end of the second year of age (6, 7). Children entering and leaving primary school receive DT vaccine.

No case of diphtheria was reported in Poland in four consecutive years 1979–82 and in three consecutive years 1984–6. However, the occurrence of one case of diphtheria in 1987 in a 5-year-old child caused great concern.

Reports of localized diphtheria outbreaks from Sweden (8) and the Federal Republic of Germany (9) showed once again that diphtheria cannot be regarded as eliminated in Europe. This prompted us to perform the study on the diphtheria immunity in various age groups in Polish population. The state of immunity to tetanus in these age groups will be presented in a separate report (10).

MATERIALS AND METHODS

Sera. Sera from 503 persons aged from 10–90 years were tested. There were 252 men and 251 women. The persons surveyed lived in Warsaw or in Warsaw and Olsztyn Provinces; some were employees at institutions and others were teachers and students at high schools and universities. There were 129 construction workers, 91 medical service workers, 64 industry workers, 49 teachers, 39 pregnant women, 96 students and 35 were of other professions.

Sera were collected in 1986–7; most were obtained from laboratories performing routine laboratory tests in healthy persons. The collection of sera was not made randomly but efforts were made to select sera randomly from those available in the laboratory on a particular day.

Methods. The activity of diphtheria antibody was determined by the passive haemagglutination method (11), using formalinized sheep red cells sensitized with the purified diphtheria toxoid lots Di-A and Di-Z, containing 2300 and 2400 Lf/ml, respectively, from the Statens Seruminstitut in Copenhagen. In each run, a control with the standard antitoxin was set up and the results were expressed in the international units (IU) per ml.

Our previous experience showed that titers of diphtheria antibody, determined

Table 2. *Distribution of titres of diphtheria antibody determined by the passive haemagglutination method in 503 sera of persons aged 10–90 years, Poland 1986–7*

Age groups in years	No. of serum samples	% of samples with titres (IU/ml)			
		< 0·1	0·1–0·9	1·0–9·9	> 10
10–19	9	11	11	56	22
20–29	150	51	26	23	—
30–39	96	49	40	11	—
40–49	98	64	27	9	—
50–59	106	59	26	13	2
60–90	44	46	41	9	5
Total	503	53	30	16	1

in 516 adult sera, were similar in the *in vitro* haemagglutination and *in vivo* neutralization method in rabbits. The regression equation showing the relationship between these two methods was TN = 0·94 + 0·12 HA (12).

In the present study the titer of 0·1 IU/ml was considered as the protective level. The geometrical mean was calculated by assuming that titer lower than the lowest measurable level (0·06 IU/ml) is four times lower (0·015 IU/ml).

RESULTS

Overall diphtheria immunity. Nearly half of tested persons had diphtheria antibody levels above 0·1 IU/ml and 17% had high antibody levels of 1 IU/ml or more (Table 2). The overall geometrical mean of diphtheria antibody was 0·11 IU/ml.

Diphtheria immunity by age groups. The proportion of those tested who had adequate levels of diphtheria antibody was the highest in the 10–20 year-old-age group (Table 2) and decreased subsequently with the increasing age, to reach the lowest point, 36%, in the 40- to 49-year-old group. The figure rose again to 55% in the over 60 group.

The changes in the diphtheria immunity in the last 30 years, 1954–84, are shown in Fig. 1. In 1954–5, before the introduction of mass immunization of children against diphtheria, children below 5 years of age were the most susceptible to diphtheria when tested by the Schick test (14) – only 30% being negative. The early impact of mass immunization was seen in 1973 when about 80% of children in age groups 1–14 years had diphtheria antibody levels of 0·1 IU/ml or more (13). In 1971–6, the most susceptible group was the 25–35 year olds (5, 12) and in 1986–7 the 40–50 year olds.

Diphtheria immunity by sex and profession. There were no clear differences in immunity between males and females (Fig. 2) or among various professional groups which ranged from 41% for teachers to 56% for industrial workers.

The relationship between diphtheria and tetanus antibody levels. There was no clear relationship between diphtheria and tetanus antibody levels. Among 269 persons with diphtheria antibody levels of less than 0·1 IU/ml, 153 persons (57%) had a high tetanus antibody levels of 1 IU/ml or more (Table 3).

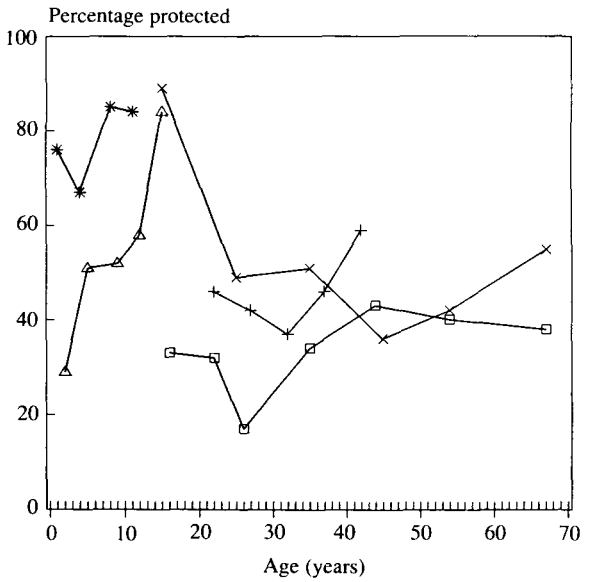

Fig. 1. Diphtheria immunity by age, Poland 1954–87. For 1971, 1973, 1976 and 1987: the hemagglutination antibody level of 0·1 IU/ml or more; for 1954–55: the negative Schick test. △, 1954–5; +, 1971; *, 1973; □, 1976; ×, 1987. (According to: Galazka & Sporzynska (5, 12); Anusz & Abgarowicz (13); Daniel et al. (14).)

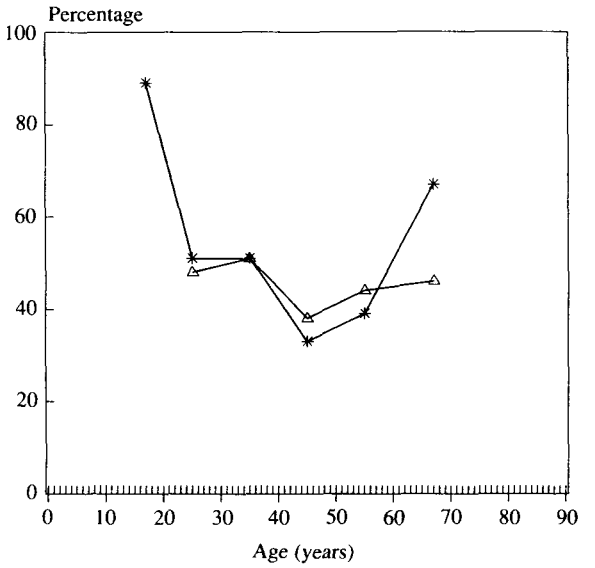

Fig. 2. Diphtheria immunity by age and sex, Poland, 1986–7. Percentage of persons with antibody level of 0·1 IU/ml or more. △, Males; *, females.

DISCUSSION

The marked decrease, and in some industrialized countries the virtual elimination of diphtheria over last three decades is attributable to successful immunization programmes. However, even in those countries, diphtheria has

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Table 3. *Distribution of the diphtheria and tetanus antibody titres in sera of 503 persons aged 10 to 90 years, Poland 1986–7*

No. of persons with diphtheria antibody levels (IU/ml) of	No. of persons with tetanus antibody levels (IU/ml) of					
					Total	
	< 0·1	0·1–0·9	1·0–9·9	> 10·0	No.	%
< 0·1	69	47	100	53	269	53·5
0·1–0·9	25	31	55	39	150	29·8
1·0–9·9	5	4	29	40	78	15·5
> 10·0	—	1	1	4	6	1·2
Total						
No.	99	83	185	136	503	100
%	19·7	16·5	36·8	27·0	100	

reoccurred from time to time in more or less limited outbreaks, especially in areas where immunization coverage among children has fallen.

In the early and mid-1980s an increased diphtheria incidence was reported from Sweden, the Federal Republic of Germany (FRG), USSR, Turkey and Portugal (4). In the German Democratic Republic (GDR) three cases of diphtheria occurred in 1986–7 after 12 years of freedom from indigenous diphtheria (17). In the USSR more than 1000 cases are reported annually (3).

In Poland single cases of diphtheria were reported in 1978, 1983 and 1987, separated by 5 and 4 years of freedom from the disease (2).

In many of these outbreaks, adolescents and adults were mainly affected and it was suggested that adults might become again susceptible to diphtheria due to reduced opportunity for acquiring or reinforcing natural immunity through subclinical infection (4).

Results of the present study demonstrate a high level of diphtheria immunity in persons below the age of 20 years and a low level of diphtheria immunity among adults in Poland. The high diphtheria immunity level in younger persons was presumably the result of the routine immunization with the series of vaccines containing diphtheria toxoid (four doses of DPT and two doses of DT) with the last dose of DT vaccine given within the obligatory schedule at about 14 years of age. Only between 36 and 50% of persons surveyed between the ages of 20 and 60 are immune for diphtheria. The most susceptible age groups have tended to get older over the last 15 years, from 25–35 years in 1971–6 to 40–50 years in 1986–7.

That older adults seem to be better protected against diphtheria than those of middle age might be because they maintained natural immunity solidly built up in the 1950s, i.e. in the years when Poland suffered from very severe diphtheria epidemics with 20000–40000 cases per year.

The phenomenon of decreasing immunity to diphtheria among adults has been observed in many countries (17–26). Although the direct comparison of immunity levels in different countries is complicated by different methods used for determining diphtheria immunity in various populations, some common characteristics may be emphasized. Children in most countries seem to be highly immune to diphtheria although there are clear differences between individual

countries (17, 21, 24–26). The proportion of people with protective levels decreases with age. The most susceptible age group in the GDR, FRG, USSR and Japan is the 20–40 year olds (17–20, 22, 26) in Poland, Australia and England the 40–50 year olds (21, 23) and in Denmark, Sweden, Finland and USA the over 50 year olds (8, 15, 16, 24).

It is interesting that in other countries too elderly persons remain immune to diphtheria due probably to their natural immunity, acquired during past epidemics (15, 18, 22, 23, 26). This is in a clear contrast to the age-related immunity against tetanus, where the oldest groups of population show the lowest immunity levels (10).

There is no clear difference in the diphtheria immunity among males and females in Poland (Fig. 2), a similar finding to that reported from the USA (15). In contrast, in Denmark and Sweden, the immunity among men older than 20 years of age was higher than among women because many men in these countries receive booster injections of diphtheria-tetanus toxoid during their compulsory military services (8, 16).

A large pool of susceptible persons creates an epidemic potential and therefore the diphtheria immunity status of the population should be periodically assessed to monitor the efficacy of immunization programme in children and to evaluate the changes in immune status in adults.

Although the epidemiological situation with regard to diphtheria in Poland is favourable, there is no room for complacency and the maintenance of DPT and DT immunization coverage in children should be a priority. The introduction of the adult type tetanus and diphtheria toxoids (Td) into routine immunization schedules should however, be considered. Although such a vaccine, tested in 1962, showed a good booster effect and few adverse reactions in schoolchildren, in a primary course of two doses it was less immunogenic than the childhood type of DT vaccine containing the full strength amount of diphtheria toxoid (27).

This vaccine should be recommended for use particularly in persons vulnerable to the acquisition of virulent *C. diphtheriae* such as those travelling to developing countries, personnel in military service, medical service staff, kindergarten and creche personnel, teachers, college and university students. Consideration of the proposal of Karzon & Edwards (28) to immunize adults with Td every 10 years and to give that vaccine whenever tetanus toxoid is indicated (e.g. in treating wounds in emergency rooms) could provide a stimulus towards addressing the problem of reinforcing diphtheria immunity in adults.

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