Declining population immunity to mumps among Israeli military recruits

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Abstract

Population-based seroepidemologic data on mumps have not been available in Israel since 1987, and the effects of mass immigration from the Commonwealth of Independent States during the 1990s have not been investigated. We conducted a seroprevalence study of mumps antibodies among 353 Israeli military recruits aged 18–19, based on a representative sample of sera collected in 1999. The overall seroprevalence rate was 83.3%, which was significantly lower than that measured in 1987 (94.1%, P < 0.001). Foreign-born subjects had substantially lower seroprevalence rates than their native Israeli counterparts (68.5% versus 86.1%, P < 0.001). Recent seroprevalence levels are below those required for herd immunity, and most likely contributed to an outbreak of mumps observed among young adults in Israel in 2005. Immigration appears to be a contributing factor to the decrease in population seroprevalence over time.

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1. Introduction

Mumps is an acute infectious disease caused by a paramyxovirus. The disease is usually mild, but up to 10% of patients develop aseptic meningitis, and others suffer encephalitis, a less common but more serious complication which can result in death or disability [1]. Additional complications of mumps include deafness, nephritis, orchitis, and pancreatitis [1–3]. Live attenuated vaccines against mumps have been available since the 1960s, and more than 10 mumps virus strains are now used in the production of vaccine worldwide [4]. Mumps vaccines are currently in widespread use, and are included in the national immunization programs of 92% of developed countries, 86% of countries in economic transition and 24% of developing countries [1]. Countries with a high level of vaccine coverage have shown a rapid decline in mumps morbidity and mumps-related hospitalizations [5], and in many of these countries mumps-associated encephalitis and deafness have nearly vanished. Despite the success of vaccine in curbing disease rates, the declining incidence of mumps over time and the negative publicity recently associated with the measles–mumps–rubella vaccine have contributed to a decline in vaccine coverage rates among target populations [6,7]. Incomplete paediatric vaccine coverage and shifting patterns of natural virus transmission create conditions for a decrease in population immunity to levels below those required for herd immunity [8]. Thus, it is important for countries that routinely use mumps vaccine to maintain surveillance of population immunity, in order to identify population groups with an increased susceptibility to disease.

Mumps vaccine has been administered routinely to children in Israel since December 1988 as part of the national immunization program, and vaccine coverage is estimated to be approximately 95% [9]. Although childhood vaccine coverage is high, specific subpopulations, such as young adults born before the routine introduction of the mumps vaccine, remain susceptible to mumps outbreaks due to low seroprevalence rates. In 2005, an outbreak of mumps was...
observed among young adults in Israel. Within a period of 3 months, over 30 laboratory-confirmed cases of mumps were reported among adolescents and adults aged 17–25. Cases were detected in three clusters, and all were traced to index cases within the Israel Defense Force (IDF). This outbreak prompted us to investigate seroprevalence rates to mumps among young adults recruited to the IDF, in order to support health policy decisions. The last seroepidemiological study of the prevalence of mumps antibodies among recruits was carried out 1987, prior to the widespread immigration to Israel from countries of the former Soviet Union which took place during the 1990s [10]. Results of this earlier study demonstrated that 92.8% of females and 95.2% of males recruited to the IDF had positive assays for mumps antibodies. Considering the possibility of declining population immunity to mumps over time, especially in light of immigration patterns during the 1990s, we set out to re-evaluate the seroprevalence of mumps antibodies among recruits; to compare these results to those seen in previous studies; and to investigate immigration as a possible source of shifting population immunity.

2. Materials and methods

2.1. Study population

We studied the prevalence of mumps antibodies among IDF recruits entering service in 1999. Our random study sample was drawn from an ongoing, large-scale prospective survey on medical status, health behavior and attitudes routinely carried out among a fixed proportion of IDF recruits upon induction, 95% of whom are aged 18–19. This is the same ongoing survey from which Danon et al. drew the sample for their 1987 mumps seroprevalence study [10]. The selection process for the survey is systematic and includes a fixed percentage of recruited male and female soldiers, based on a code calculated from the subjects’ serial numbers. Military service is mandatory in Israel, although several minority groups such as ultra-orthodox Jews, religious women, most Arabs and persons with significant mental or physical disabilities are exempted from service. Thus, the survey provides a representative sample of the majority of the 18- to 19-year-old Israeli population. The selected serum samples were withdrawn from our serum bank for laboratory testing, and subjects’ pre-recorded demographic data were accessed from our computerized database. The study was approved by the IDF Helsinki Committee, and written informed consent was obtained from all selected recruits prior to entry into the survey.

2.2. Laboratory samples

Blood samples were drawn from the antecubital veins of study participants on the day of recruitment, and were stored at room temperature for up to 1 h. Samples were then refrigerated for up to 2 h at 4–8 °C, and were centrifuged for serum separation. Serum was then frozen at −20 °C and stored at the IDF Health Surveillance Serum Bank until analysis. Assay of mumps-specific IgG-class antibodies was performed at the central IDF laboratory using a qualitative immunoenzymatic ELISA kit (Mumps Virus IgG-ELISA, NovaTec, Dietzenbach, Germany) according to the manufacturer’s instructions. Sample handling, laboratory methods and serological test validity were similar to those employed in the 1987 study [10,11]. In both studies, equivocal results were considered negative, and seroprevalence rates were calculated based on positive results only.

3. Results

Serum samples with matched demographic data were available for 353 subjects, of whom 199 (56.4%) were male and 154 (43.6%) were female. Overall, 294 subjects (83.3%) were seropositive for mumps (95% CI 79.0–87.0%). Among males, 171 of 199 subjects (85.9%) were seropositive (95% CI 80.3–90.4%), and among females, 123 of 154 subjects (79.9%) were seropositive (95% CI 72.7–85.9). The 6% absolute difference in seroprevalence between males and females was not statistically significant (P for two-tailed χ²-test = 0.13).

Of the 353 subjects, 288 (81.6%) were Israeli-born and 54 (15.3%) were born in the Commonwealth of Independent States (CIS), i.e. countries of the former Soviet Union. Eleven subjects (3.1%) born in several countries other than those of the CIS were excluded from this analysis due to their low individual frequencies. Seroprevalence was significantly higher among native Israelis than among immigrants (86.1% versus 68.5%, P = 0.001) (Table 1). No significant differences in seroprevalence rates were observed between males and females among native Israelis (88.7% versus 82.9%, P = 0.21) nor among immigrants (71.4% versus 63.2%, P = 0.75). However, native Israelis demonstrated

<table>
<thead>
<tr>
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<th>Native Israelis N (%)</th>
<th>Immigrants a N (%)</th>
<th>P-value</th>
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</thead>
<tbody>
<tr>
<td>Males</td>
<td>141/159 (88.7)</td>
<td>25/35 (71.4)</td>
<td>0.009</td>
</tr>
<tr>
<td>Females</td>
<td>107/129 (82.9)</td>
<td>12/19 (63.2)</td>
<td>0.042</td>
</tr>
<tr>
<td>Total</td>
<td>248/288 (86.1)</td>
<td>37/54 (68.5)</td>
<td>0.001</td>
</tr>
</tbody>
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a Analysis limited to immigrants from Commonwealth of Independent States.
higher seroprevalence rates than immigrants both among males (88.7% versus 71.4%, \( P = 0.009 \)) and among females (82.9% versus 63.2%, \( P = 0.042 \)).

Mumps seroprevalence was lower among recruits in 1999 than it was in 1987 (83.3% versus 94.1%, \( P < 0.001 \)) (Table 2). Among males, there was an absolute decrease of 9.3% in the proportion of seropositives over this 12-year interval (95% CI 3.3–15.3%, \( P = 0.001 \)), and among females there was an absolute decrease of 12.9% (95% CI 5.1–20.7%, \( P < 0.001 \)). Immigration data were not available for the 1987 sample.

### 4. Discussion

During the late 1970s and through the 1980s, the annual incidence of mumps in Israel ranged from 80 to 160 cases per 100,000, with the vast majority of cases appearing during early childhood (Fig. 1). A live attenuated mumps vaccine was first introduced in Israel in 1984 as a single dose measles–mumps vaccine. This dosing schedule was discontinued, however, in 1985. Birth cohorts from 1988 and onward received the measles–mumps–rubella (MMR) vaccine at 12–15 months of age, with a booster dose added at the age of six starting in 1994 [13]. A rapid decrease in the incidence of mumps followed the introduction of routine vaccination, with annual rates reaching 6–17 cases per 100,000 during the early 1990s [14,15]. After the addition of the second MMR dose in 1994, mumps incidence rates dropped to less than 1 case per 100,000 [14]. While disease trends in the military have closely followed those observed in the general population, the civilian rates dropped to levels consistently lower than the military rates subsequent to the introduction of MMR vaccination. In 2005, the mumps outbreak observed among young adults, most of whom were serving in the IDF at the time, resulted in an annual military incidence rate of nearly 18 cases per 100,000, the highest rate recorded since 1994.

A large-scale nationwide mumps epidemic has been observed recently in the UK, especially among children and young adults representing the birth cohorts of 1982–1989 [16–19]. According to UK vaccination schedules, these birth cohorts received 0–1 doses of MMR vaccine in childhood [17,19]. In 2005, an outbreak of mumps was also observed in Israel among young adults aged 17–25. All cases in this outbreak were traced to a single index case, who was, at the time, a soldier in the IDF. All cases in the Israeli outbreak were born between the years 1980–1988, and like their UK counterparts, were either not vaccinated against mumps in childhood, or received only a single dose of mumps vaccine. One dose of MMR does not impart reliable immunity, and single dose vaccinees remain at significant risk of disease. In the recent UK mumps epidemic, approximately 30% of all cases reported in 2004 had received a single dose of MMR vaccine during childhood, while only 3% had received two doses [18]. In a 1999–2000 outbreak of mumps in Northern Ireland, more than 50% of 332 laboratory-confirmed mumps cases had received a single dose of MMR vaccine during childhood, while fewer than 1% of cases had received 2 doses [20]. Similar findings were present in an outbreak among schoolchildren and adolescents in England in 2000 [16]. The low incidence of mumps among children who had received two doses of MMR illustrates the importance of the second dose of MMR for full protection.

Susceptibility to mumps is especially important in environments where unvaccinated young people congregate in close quarters, such as in dormitories, on college campuses.
and in the military [4,18,21]. Prolonged mutual exposure of large groups of people facilitates the spread of mumps, which is communicated by airborne transmission, droplet nuclei spread and direct contact with infected saliva and fomites [22]. The main factor which limits the formation of large epidemics under these conditions is the herd immunity, which is the level of immunity in a population at which the proportion of susceptibles is so low that a contagious individual will infect, on average, no more than one additional person, thus creating conditions unfavorable for epidemic transmission. Herd immunity for mumps is estimated to be 90–92% [8,10]. This level is well above that observed in the study population, suggesting that IDF personnel may be at risk for future mumps outbreaks. However, since 3-year mandatory military service in Israel starts at age 18, the birth cohort of 1988, which was vaccinated twice with MMR during childhood, is expected to populate the IDF in 2006, and by the end of 2008 nearly all mandatory servicemen and women will have been effectively vaccinated against mumps with two doses of MMR during childhood. While this scenario may accurately describe the future seroepidemiology of young, native Israeli adults, it does not hold true for immigrants, since no effective catch-up programs targeting this sub-population are currently in place in Israel.

Our findings indicate that the recent mumps outbreak identified among young adults in Israel was facilitated by a downward trend in antibody prevalence to levels below those required to maintain herd immunity. This is most likely due to decreased viral circulation and less frequent natural exposure and acquisition of immunity since the introduction of widespread vaccination in 1988, coupled with the influx of non-vaccinated children and young adults from the CIS over the last decade. Since both the native and immigrant subjects studied were unvaccinated during childhood, the higher seroprevalence rate observed among Israeli-born young adults is probably due to factors associated with greater natural exposure in this group, such as larger family size and poorer childhood environmental hygiene. So long as these immigration-associated factors have remained constant, they have likely exerted similar effects on consecutive birth cohorts. Should these differences diminish over time, however, the lower seroprevalence rate among immigrants would represent less of a contribution to the overall decrease in herd immunity within subsequent birth cohorts.

The recent mumps outbreaks among young adults in Israel and the UK should serve as a reminder of the possible long-term effects of childhood vaccination programs with incomplete catch-up contingencies. In countries where mumps is targeted for elimination, a second dose of mumps vaccine should be added for children, keeping in mind that the disease may still occur in susceptible adults [1,5].

References