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MUMPS VACCINATION IN THE FINNISH DEFENSE FORCES[1]

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Penttinen, K., (Univ. of Helsinki, Helsinki 25, Finland), K. Cantell, P. Somer and A. Poikolainen. Mumps vaccination in the Finnish Defense Forces. *Amer. J. Epid.*, 1968, 88: 234–244.—Inactivated mumps vaccine has been routinely used in the Finnish Defense Forces since 1960. By the end of 1966, over 200,000 servicemen (about 95%) had received two injections of the vaccine in the beginning of their 8 to 11 months' service. No complications were seen except for a few local reactions. The seroconversion rate as measured by the complement fixation test varied between 73 and 92% in different years.

The mean incidence of mumps during 1955–1959 was 31 per thousand; the corresponding figure for 1961–1966 was 1.9, a 94% reduction. Before the vaccination period the number of mumps cases in the forces was about 10% of the reported number of mumps cases in the whole country. After the vaccination was started the corresponding percentage decreased more than tenfold. An analysis of the mumps cases occurring during the vaccination period revealed that 1) nonvaccinated men contracted mumps about ten times more frequently than the vaccinees, 2) men from rural areas had mumps about twice as often as men from urban areas, 3) the highest incidence of mumps occurred during the first month of the service, i.e., before the vaccination was completed, 4) the frequency of orchitis as a complication of mumps was 2–3 times lower among the vaccinees than among nonvaccinated men, 5) the orchitis rate was 25 times lower among the vaccinees than among nonvaccinated men.

Military service constitutes a risk period as far as mumps and its complications are concerned. It appears that the risk can be safely and effectively reduced by the inactivated mumps vaccine.

Mumps with complicating orchitis has always been a medical problem among servicemen, especially in wartime. During World War II, the frequency of mumps cases among recruits in Finland reached 250–300 cases per 1,000 men (1). In the United States the corresponding figure among recruits from rural areas was 75 (2). The frequency of mumps in the Finnish defense forces has remained high even in peacetime (table 1). Not only is time lost in sick-leave (on the average 14 days per case), but the orchitic sequelae of mumps may have lifelong consequences. About 15–

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25 per cent of men contracting mumps develop orchitis and about 10–20 per cent of these cases are bilateral and may lead to sterility and persistent hormonal disturbances (3). Mumps infection contracted during military service has been a common cause of sterility in Finland, as strongly suggested by an analysis of 658 sterile couples (4). Thirteen per cent of all the husbands and 23 per cent of the aspermic husbands had had orchitis parotidea. In 51 per cent of these cases the orchitis had occurred during compulsory military service.

In attempts to prevent mumps and/or orchitis, convalescent serum, gamma gobulin or steroid hormones have been given but with rather unsatisfactory results (5–9). Vaccination trials showed that some degree of protection against mumps could be obtained with inactivated vaccine (10–13). Intracutaneous injections of blood taken from mumps patients at the height of the disease were also used earlier with some success (14). Live mumps vaccines have later been successfully employed in both the U.S.A. (15–17) and the U.S.S.R. (18, 19). The first trial of inactivated vaccine for the prevention of mumps in the Finnish defense forces was made in 1953 and a 50 per cent reduction in mumps cases and a 95 per cent reduction in orchitis cases was achieved (20). Since 1960, mumps vaccination has been routine in the Finnish defense forces. The experiences accumulated during these seven years of mumps vaccination are described in the present report.

Material and methods

Military service in Finland. As a general rule young men begin their compulsory national service in their twentieth year. New recruits are enlisted three times a year, on February 15, June 15 and October 15. The service lasts 8 months for 55–60 per cent of these servicemen and 11 months for the other 40–45 per cent. The latter group comprises the men to be trained for higher ranks as well as special servicemen.

Table 1

*Incidence of mumps in the Finnish Defense Forces in 1929–1959**

Year	Cases	Cases per 1,000 men	Year	Cases	Cases per 1,000 men
1929	1,012	41	1947	557	19
1930	881	35	1948	1,023	34
1931	846	33	1949	576	19
1932	586	23	1950	721	24
1933	1,389	56	1951	507	17
1934	1,291	52	1952	802	27
1935	2,834	113	1953	734	24
1936	3,658	142	1954	920	29
1937	2,164	87	1955	671	21
1938	1,274	50	1956	926	29
1939	1,254	50	1957	1,109	35
			1958	1,424	44
1945	108	3.6	1959	923	28
1946	24	0.8			

* The figures for the war years were not available.

Mumps vaccine. The Enders strain of mumps virus was used for the production of virus allantoic fluids in chick embryos. The virus was inactivated with 0.1 per cent formalin for one week at +4 C and purified by centrifugation in a CEPA centrifuge. The potency of the final vaccine was standardized by hemagglutination (HA) titration before and after sonication of the vaccine (21, 22). The vaccine batches contained 300–1,000 HA sonic units per dose (table 3). The nitrogen content of the vaccine was also determined. The vac-

TABLE 2
The extent of vaccinations in 1960–1965

	Number	Per cent
Two vaccinations	154,973	95.5
Second vaccination not done	6,333	3.9
No vaccination	1,053	0.6
Total number of recruits	162,359	100.0

cine contained as preservatives 0.5 per cent phenol and 0.1 per cent merthiolate.

Vaccination. The recruits received two 0.5 ml subcutaneous doses of vaccine at intervals of 2 to 4 weeks. The first injection was given at the first opportunity after enlistment.

Collection of paired sera and titrations. Paired sera were collected at random from 0.5 to 1.0 per cent of the vaccines. Altogether, 1,298 paired sera were obtained during the years 1960–1965 and titrated in the complement fixation (CF) test with mumps virus allantoic fluid as antigen; 904 paired sera were titrated with both mumps and parainfluenza 1 (Sendai) antigens (23). The CF-technique was that of Dumbell and Fulton (24), with minor modifications. The dilution series ranged from 1/4 to 1/64. All the titers are expressed as reciprocals and the titer <4 is taken as 2 in the calculations.

Collection of clinical data. The cases of mumps reported were hospitalized and any tenderness of the testes even without swelling was considered to be orchitis. The 393 case records available were collected and analyzed by the same person: 18 case records were missing.

Statistical data. The Central Statistical Bureau of Finland supplied the data concerning the numbers of men living in rural and urban areas. The statistical bureau of the National Medical Board supplied the data for the incidence of mumps. The figures represent only a sample drawn similarly each year and not the exact number of cases. The figures for the defense forces are included in data for the whole country.

RESULTS

Extent and safety of vaccinations. As a first step, recruits were questioned about allergy to eggs, and those who claimed to be allergic were not vaccinated. For various reasons (leave, hospitalization, travel) the second vaccination was missed by some of the recruits. The extent of the vaccinations during the years 1960–1965 is given in table 2.

According to table 2, 95.5 per cent of the recruits received both injections in the beginning of their military service. By the end of 1966, over 200,000 recruits had received two injections of inactivated mumps vaccine. Local reactions at the site of vaccination seldom occurred. No other complications have been reported.

Serologic studies. These were made to gain an idea of the immunity status of the recruits and to check the efficacy of the different batches of vaccine. There were annual variations in the percentage of seronegative recruits (table 3 and figure 1). The figures show a parallelism with the numbers of mumps cases notified in Finland as a whole (figure 1). When the percentage of seronegative servicemen was low, the number of mumps cases in the country was at a low level. The incidence of mumps was positively correlated with the percentage of seronegative servicemen. The appearance of detectable antibodies in

the postvaccination sera of the men lacking mumps antibodies was considered to indicate serologic conversion. Table 3 shows that the conversion rate was lowest in 1963 (73 per cent) and highest in 1961–1962 (91–92 per cent). The percentage of vaccinees remaining seronegative was highest in 1963 (9.5 per cent) and lowest in 1961–1962 (2.8–3.1 per cent). Table 3 also shows that the mean HA titer of the batches of vaccines used was lowest in 1963 and highest in 1962.

Incidence of mumps in the defense forces during the vaccination period. In the period of 1961–1966, when vaccination was available to all recruits, 411 cases of mumps were recorded in the defense forces. This figure includes 11 cases from among commissioned ranks. These were mostly nonvaccinated. The distribution of cases among the different years, as well as the incidence per thousand men, are seen in table 4. Table 5 summarizes the incidence of mumps during two six-year periods, one before, the other after the year vaccination was started. The mean incidence of mumps dropped from 31 to 1.9 per thousand, which corresponds to a 94 per cent reduction.

Thus, 400 cases of mumps occurred during the vaccination period among the servicemen and, according to the records, 24 of these men had not received any mumps vaccinations. This accounts for 6 per cent of the mumps cases. According to table 2, the proportion of nonvaccinated servicemen was 0.6 per cent; thus the morbidity among the nonvaccinated men was ten times that among the vaccinees.

The number of mumps cases in the

TABLE 3

Serologic response to mumps vaccine. Some data on vaccines used

Year	Number of paired sera	Titer <4 before vaccination (per cent)	Conversion rate (per cent)	Titer <4 after vaccination (per cent)	Vaccine	
					HA/HA-sonic titer	γN/ml
1960	151	48	86	6.6		26
1961	215	36	92	2.8	220/500	27
1962	162	33	91	3.1	330/1070	36
1963	221	35	73	9.5	128/310	35
1964	269	40	78	8.9	256/810	24
1965	280	44	85	6.8	140/870	22

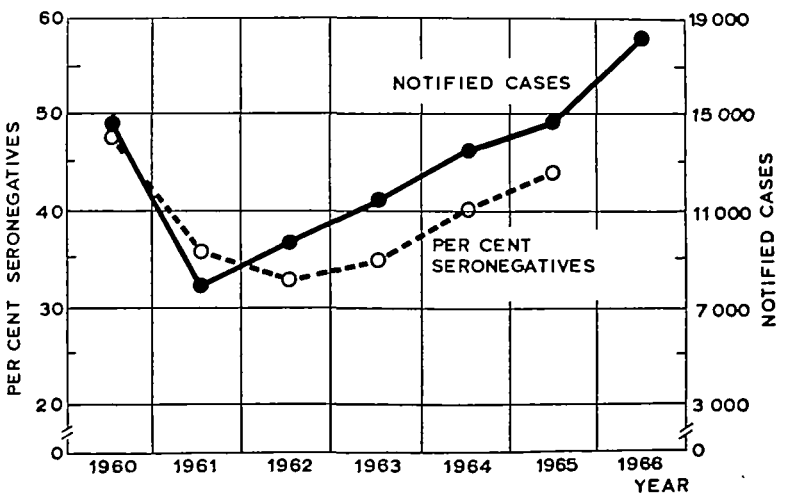

FIGURE 1. Notified cases of mumps in Finland and percentages of servicemen seronegative at the beginning of their military service, 1960–1966.

TABLE 4

Incidence of mumps in the Defense Forces in 1961–1966

Year	Number of cases	Cases per 1,000 men
1961	63	1.8
1962	22	0.7
1963	103	2.9
1964	64	1.7
1965	69	1.9
1966	90	2.2
Mean	69	1.9

TABLE 5

Incidence of mumps in the Defense Forces during a six-year period before and after the beginning of vaccination

Years	Number of cases	Mean number of cases per year	Cases per 1,000 men
1954–1959	5,974	996	31
1960	360	360	11
1961–1966	411	69	1.9

defense forces as compared to the number of notified cases in the whole of Finland. According to tables 4 and 5, it is evident that a marked reduction occurred in the incidence of mumps in the defense forces after the routine vaccination of recruits. It is known that the incidence of mumps may show great variations in successive years and that epidemics may be separated by long intervals (3). It was thus of interest to compare the incidence in Finland with the incidence in the defense forces. This comparison is shown in figure 2, from which it can be concluded that before the vaccination period the incidence of mumps in the forces was roughly ten per cent of the reported incidence in the whole country, but that during the vaccination period it decreased to less than one per cent.

Monthly distribution of mumps cases. The monthly distribution of mumps cases in the defense forces before and

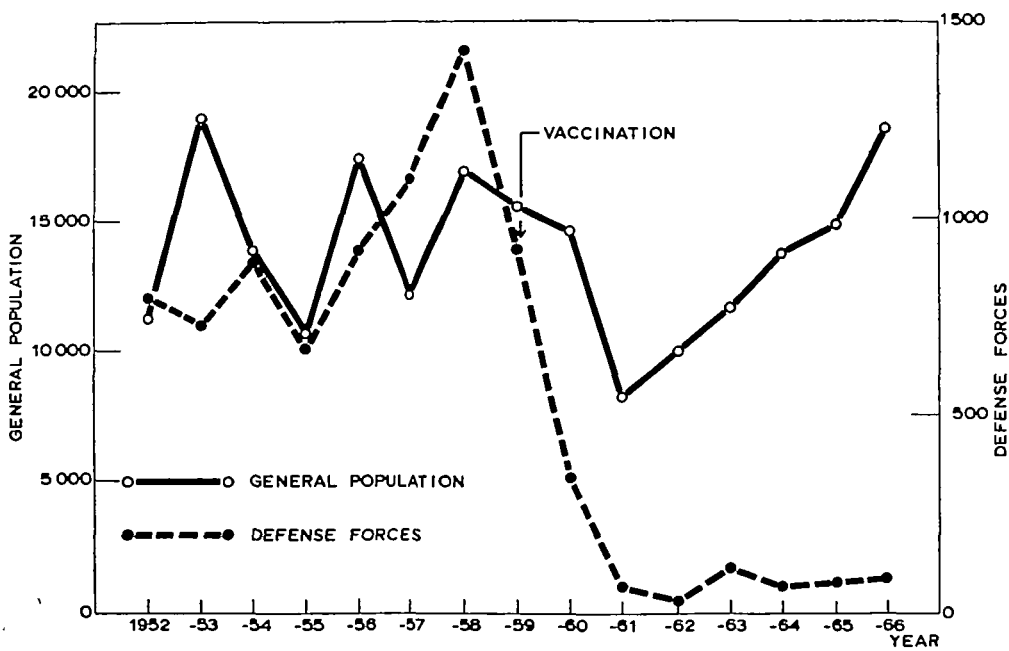

FIGURE 2. Notified cases of mumps in the general population and in the defense forces, 1952–1966.

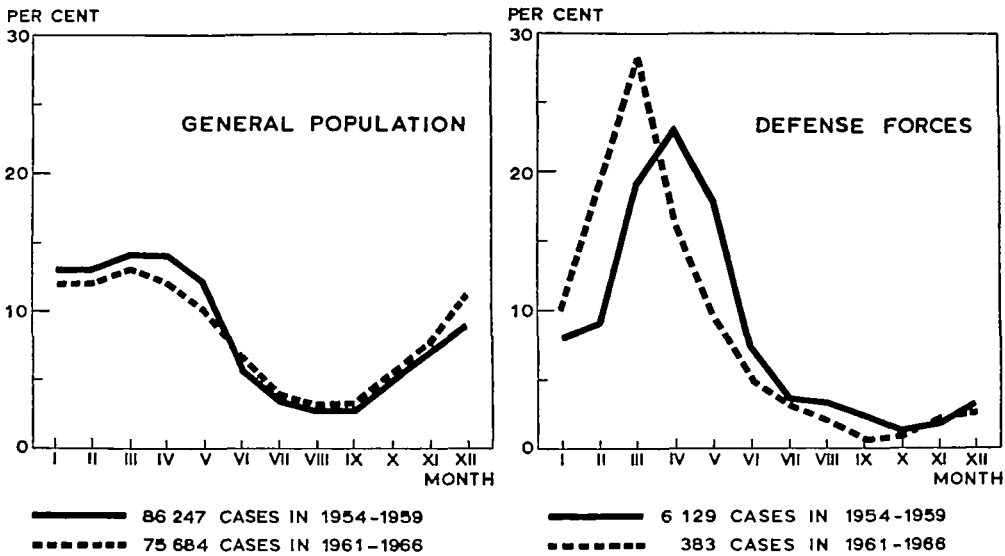

FIGURE 3. Monthly percentage distribution of notified mumps cases.

during the vaccination period, as well as the monthly distribution of all notified cases in Finland during the corresponding periods is shown in figure 3. It demonstrates the similarity of the seasonal distribution of notified cases in the country as a whole during the two periods studied. The distribution curve for the defense forces has more accentuated peaks, especially during the vaccination period, when 28 per cent of cases occurred in March and 0.5 per cent in September.

The distribution of the mumps cases occurring during the vaccination period was analyzed according to the number of months the patients had been in military service. The necessary data were available in 357 case records and the results are given in table 6. The highest incidence is in the first month of service, i.e., before the vaccinations were completed.

Mumps cases among national servicemen from urban and rural areas. According to the available case records of the mumps cases from the years 1961–1966, 81 of the 382 servicemen (21 per cent) came from urban areas. During the same period 41 per cent of the male twenty-year-old population in Finland was living in urban areas. Accordingly, the number of patients from urban areas was only half of the expected figure.

TABLE 6

Distribution of cases of mumps according to the month of military service

Years	Month of military service								Total
	I	II	III	IV	V	VI	VII	VIII–XI	
1961–1966	75	30	32	32	41	50	44	53	357

Orchitis during the vaccination period. Among the 411 cases of mumps 35 cases of orchitis were reported. Four of these were bilateral. One case with a recurrence three weeks later did not have preceding swelling of the parotid glands, which makes the diagnosis uncertain. The case is nevertheless included in the group of complete vaccinations among servicemen. The orchitis

TABLE 7

Vaccination status of the orchitis cases

	All ranks	Servicemen only
Number of cases	35	31
Complete vaccination	12	11
One vaccination	9	9
No vaccination	6	3
No information	8	8

TABLE 8

Orchitis rates among servicemen according to vaccination status

Vaccination status	Cases of orchitis	Number of servicemen	Orchitis rate per 10,000
Two vaccinations*	19	191,000	1
One vaccination	9	7,800	12
No vaccination	3	1,200	25

* Also contains eight cases without information of vaccination status.

TABLE 9

Orchitis frequencies in the Finnish Defense Forces in 1958–1959

	Cases of mumps	Cases of orchitis	
	Number	Number	Per cent
1. Study of Penttinen et al. in 1953	86	18	21.0
2. Study of Klemola and Somer in 1954–1955	643	108	16.8
3. Figures from military hospitals with available statistics for orchitis in 1957–1959	1,445	227	15.7
4. All data combined	2,174	353	16.3

cases and their vaccination status are presented in table 7.

It can be concluded from table 7 that the nonvaccinated and partially vaccinated servicemen ran a considerably greater risk of contracting mumps orchitis than the servicemen who had been completely vaccinated. In table 8 the orchitis rates are calculated on the basis of the vaccination status among 200,000 servicemen (table 2). Even though all the cases for which adequate information about vaccination was lacking were taken as completely vaccinated, the protection rate was 25.

Most of the orchitis cases occurred during the first two months of service. The lowest incidences of orchitis among mumps cases were recorded in the years 1962 and 1964. The respective rates were 0/22 and 2/64.

The frequency of orchitis as a complication of mumps among the once or twice vaccinated servicemen (376) does not exceed 7.2 per cent. The frequency of orchitis in the Finnish defense forces before 1960 is not available, but a rough estimation can be achieved from the available data, which are presented in table 9. In the period 1961–1966, 32 nonvaccinated men contracting mumps were recorded. Twenty-four of them were servicemen and eight from among commissioned ranks. The percentage of orchitis in this nonvaccinated small group was 19 (six cases).

Mumps and orchitis among commissioned ranks. As mentioned earlier, the reported 411 mumps cases during the vaccination period include 11 cases from among the commissioned ranks. Eight of these had not been vaccinated against mumps. Three cases of orchitis were observed among them. No information concerning vaccination was available in one case of mumps.

In two cases mumps vaccination had been given three years before, during military service. One patient had received one and the other two injections. The disease ran the usual course and

was followed by orchitis in the latter case.

Discussion

Earlier studies with formolized mumps vaccine in Finland (20) as well as in the U.S.A. (10–13) showed that killed vaccine is effective in reducing the numbers of cases of mumps and of complicating orchitis. In the present study the reduction of the frequency of mumps was found to be of the order of 94 per cent and of orchitis 96 per cent when the six-year pre- and post-vaccination periods were compared. The reduction in the number of orchitis cases is calculated on the assumption that in the pre-vaccination period 16 per cent of mumps cases were followed by orchitis (table 9). Thus, in this disease, too, an extension of vaccinations above the restricted field trial level resulted in better protection than was to be expected. The increased dose of virus antigen injected during the routine vaccination probably also had an influence.

There are at least two possible reasons, however, why the number of mumps cases in the defense forces might have declined even without vaccination. First, the number of notified cases in the whole country (figure 3) was 10,590 cases less during the latter period than during the former. Since the figures for the defense forces are also included in the official statistics, the reduction through vaccination in the defense forces is also reflected in those figures. Thus only a 6 per cent reduction in the official statistics (*c.* 5,000 cases) is probably independent of vaccination. The corresponding reduction, had there been no vaccination in the defense forces, would have been *c.*. 300–400 cases. As a result the calculated efficacy of the vaccine is reduced from 94 to 93 per cent. Second, another circumstance that may have changed the incidence of mumps in the Finnish defense forces irrespective of vaccination is the increasing urbanization of the population. According to the official statistics, the percentage of twenty-year-old men living in urban communities was 27 per cent in 1955, 35 per cent in 1960 and 43 per cent in 1965. This should be reflected in a higher immunity status at enlistment. The figures (figure 1), however, do not support this. On the contrary, from the year 1962 the degree of immunity among recruits seemed to be decreasing. Thus it seems that any effect urbanization may have will only be apparent after a longer period.

The difference in the efficacy of the vaccinations in the years 1962 and 1963 with mumps rates of 0.7 and 2.9 per thousand men, respectively, is noteworthy. There was no great difference in the percentage of seronegatives among the successive age classes of 1962 and 1963 (33 and 35 per cent). An explanation based on different history as regards exposure to mumps is therefore not plausible. The incidence of mumps in Finland as a whole was also of the same magnitude in the two years. According to the figures presented in table 3, the content of antigen as measured by HA titers was highest in the vaccine lots of 1962. Also the seroconversion rate was one of the best. It is likely that the best protection achieved in 1962 was due to good batches of vaccine and also that the worst protection in 1963 was due to inferior vaccine. It may be relevant that in the year 1963 the pre-existence of Sendai antibodies in sera of recruits did not enhance the homologous titer increase after mumps vaccination as it did in earlier years (23). This phe-

nomenon has been discussed in an earlier paper, and was suggested to depend on the differing quality of Sendai CF antibodies in successive age classes. Variation in the antigenicity of vaccine batches is another possible explanation.

The reduced frequency of orchitis in response to vaccination resembles the observation that the number of paralytic cases is more reduced than the number of enteric infections after polio vaccinations. It is likely that the antibody barrier in the blood affords better protection against orchitis than against infection of the salivary glands, which are nearer the primary site of virus multiplication.

The relative merits of live and killed vaccines have been much discussed. In this connection it can only be stated that published results of controlled trials with live mumps vaccines are scanty as compared with this series of more than 200,000 complete vaccinations in a population where observation had been possible and where noteworthy short-term complications are recorded. The safety of killed mumps vaccine has so far been good. A seroconversion rate of more than 90 per cent can be achieved with good batches of inactivated vaccine. The observed variation in antigenicity, if not overcome, might be regarded as a disadvantage.

The main argument against the use of inactivated mumps vaccine is that the protection it affords may be only of short duration. Therefore, as with inactivated polio vaccine, repeated vaccinations appear to be necessary to maintain immunity. No data are yet available about the duration of the immunity conferred. The low number of cases during all the months of service (table 6) suggests immunity of at least one year's duration. The wild viruses encountered during the service period may have a booster effect. The heightened risk of contracting parotitis in the defense forces with possible lifelong consequences makes vaccination desirable. A later booster dose might be considered for men exposed to mumps contracted by their own children. (But at that time they already have children.)

A special danger of vaccinating with killed vaccines has recently been described. A hypersensitivity reaction may subsequently occur when live virus from vaccine or nature meets the "sensitized" body. Such reactions have been noted with measles, where an unusual course of the disease and of skin tests had occurred in vaccinated subjects (25–28). In this study none of the 400 cases described among servicemen showed signs of hypersensitivity. The two cases of mumps contracted three years after vaccination ran a normal course. The possibility of later hypersensitivity reactions, which are by no means excluded after live virus vaccines either, will be studied later in the vaccinated population.

In conclusion, it can be said that the complete eradication of mumps and complicating orchitis from the defense forces by either killed or live vaccines is impossible, because some recruits already have the disease at the time of enlistment. A great reduction in the frequency of both mumps and orchitis in the special circumstances of the defense forces has been achieved by using inactivated vaccine.

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