Surveillance of adverse events following immunization: 10 years' experience in Oman

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ترصُّد الأحداث الضائرة التالية للتمنيع: 10 سنوات من الخبرة في سلطنة عُمان

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الخلاصة: أجرى الباحثون مراجعة مستندة على السجلات للأحداث الضائرة التي تتلو التمنيع في سلطنة عُمان، مستخدمين قاعدة معطيات للفترة 1996 – 2005. وقد تلقَّى الباحثون 790 بلاغاً من البلاغات عن الأحداث الضائرة بمعدل سنوي لفترة إجراء دراسة المراجعة بلغ 33.7 لكل مئة ألف من السكان أو 10.8 لكل مئة ألف من الجرعات المعطاة. ولم يُبلَّغ عن حدوث وفيات. وكانت أكثر الأحداث الضائرة التالية للتمنيع التي أُبْلِغ عنها التهاب العقد اللمفية التالية للقاح بي سي جي (69.7 لكل مئة ألف جرعة)، والتفاعل الموضعي (3.6 لكل مئة ألف جرعة). وتمسُّ الحاجة لمزيد من البحوث حول المعدلات الإحصائية ذات الارتفاع الذي يعتد به إحصائياً لدى الذكور، ولدى الأطفال الذين تجاوزوا السنة الثانية من العمر، وفي بعض المناطق التي يقل فيها عدد السكان في عُمان. وقد بلغت معدلات الأحداث الضائرة التالية للتمنيع مماثلة أو أخفض من المعدلات العالمية.

ABSTRACT A descriptive record-based review of adverse events following immunization (AEFI) was carried out in Oman using the national database for the period 1996–2005. A total of 790 adverse event reports were received with an annual rate during the review period of 33.7 per 100 000 population or 10.8 per 100 000 doses administered. There were no reported deaths. The most frequently reported AEFI were BCG adenitis (69.7 per 100 000 doses) and local reactions (3.6 per 100 000 doses respectively). The statistically significant higher rates among males, in children aged > 2 years and in some sparsely populated regions of Oman need further research. AEFI rates in Oman were similar or below the international averages

Surveillance des manifestations postvaccinales indésirables : dix ans d'expérience à Oman

RÉSUMÉ Une analyse descriptive basée sur les enregistrements de manifestations postvaccinales indésirables (MAPI) a été réalisée à Oman à l'aide des bases de données nationales pour la période comprise entre 1996 et 2005. Un total de 790 rapports de manifestations indésirables a été reçu avec un taux annuel au cours de la période de 33,7 pour 100 000 patients ou 10,8 pour 100 000 doses administrées. Aucun décès n'a été signalé. Les MAPI les plus fréquemment rapportées étaient la lymphadénite associée au BCG (69,7 pour 100 000 doses) et des réactions locales (3,6 pour 100 000 doses). La supériorité statistiquement significative des taux d'incidence observés chez les hommes, chez les enfants de plus de deux ans, et dans quelques régions peu peuplées d'Oman, nécessite des recherches supplémentaires. Les taux de MAPI relevés à Oman étaient semblables ou inférieurs aux moyennes internationales.

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Introduction

Vaccines, in addition to the desired outcome of provoking an immune response, may also produce some degree of unwanted (adverse) reactions. While the great majority of these are minor and harmless, a very small number are serious and potentially life-threatening. To increase acceptance of immunization and to improve the quality of services, the surveillance of adverse events following immunization (AEFI) must become an integral part of any national immunization programme.

The primary objectives of AEFI surveillance are: to monitor the trend of known adverse events; detect new, unusual or rare vaccine adverse events; determine patient risk factors for particular types of adverse events; identify vaccine lots with increased numbers or types of reported adverse events; and monitor adverse events after the marketing of newly introduced vaccines. The surveillance should also aim to identify preventable events and to take appropriate action wherever possible. A passive AEFI surveillance system seeks voluntary reports from patients visiting health care facilities and reports from health care professionals of any clinical event that occurs after vaccination, even if the reporter cannot be certain that the event was caused by the vaccine. Hence, the limitations of passive AEFI include wide variability in reporting standards, reporter bias and probably under-reporting of events.

In 2001 53% of all World Health Organization (WHO) member countries reported having a national AEFI monitoring system, an increase from 45% in 2000. The proportion among the countries of the Eastern Mediterranean Region (EMR) was 59% in the year 2001 [*1*]. In Oman, as of 2005, 10 antigens are included in the Expanded Programme on Immunization (EPI) for infants. Through an efficiently managed programme, over 95% coverage has been achieved for all vaccines since 1989. A passive AEFI surveillance programme was launched in 1996 to address vaccine safety concerns. This paper presents an analysis of the data on AEFI of childhood vaccinations reported over the 10-year period 1996–2005.

Methods

This was a record-based descriptive study of reported AEFI events in children aged < 6 years where the date of vaccination or onset of the adverse event occurred between January 1996 and December 2005.

The Oman EPI manual, with its standard operating procedures, was published by the Ministry of Health in 2003 and includes a section on AEFI [*2*]. As a Ministry of Health policy, all AEFI are required to be notified within 24 hours. All government institutions at all levels of health care offering immunization services and 16 vaccine qualified private clinics were included in the surveillance network. The EPI staff in the health care facilities were trained in the identification of events and the reporting protocol, in addition to receiving ongoing in-service training. During periodic national supervisory visits, EPI staff were updated on new and/or revised policies.

An AEFI was defined as any adverse event that occurred after a vaccination, which might be related to the vaccine itself or to its handling or administration [*2–4*]. A serious adverse event following vaccination was defined as when a patient died, experienced a life-threatening illness or required hospitalization or when the condition resulted in permanent disability.

All medical events (usual or unusual, minor or serious) related to vaccines, for which medical care was sought, were considered, including all cases of BCG lymphadenitis; injection site abscesses; and deaths, hospitalizations and other severe or unusual medical incidents that were thought by health workers or the patients, to be related to immunization. Mild episodes of fever after pentavalent vaccine or mild local pain and swelling were not required to be reported. However, reporting of vaccine sensitivity events was given precedence.

The following vaccines were studied: bacille Calmette–Guérin (BCG), hepatitis B virus (HBV), *Haemophilus influenzae* type B (Hib), measles, rubella, measles–rubella (MR), measles–mumps–rubella (MMR), oral polio vaccine (OPV), diphtheria–tetanus (DT), tetanus toxoid (TT), diphtheria–tetanus–pertussis (DTP) and pentavalent (DTP–Hib–HBV).

The data were collected by the EPI section of the Ministry of Health and compiled and analysed on a monthly basis at the national level. A modified version of the WHO recommended reporting form with standard case definitions was adopted [*3*]. Regular feedback was given through monthly reports for follow-up and action. A compiled report was submitted to the WHO Regional Office for the Eastern Mediterranean at the end of every quarter. All serious events as well as clusters of events were investigated within a reasonable time frame. In specific situations, e.g. a clustering of AEFI events following MR vaccination observed in October 1995, a detailed epidemiological investigation was conducted [*5*]. A serious adverse event following DTP vaccine administration in the year 2000 was also thoroughly investigated [*6*].

The data were compiled in Microsoft *Excel* format and data analysis was performed using *SPSS*, version 9.0. Average annual population-based rates of AEFI were calculated for different variables using the 2003 census data. Dose-related AEFI rates were calculated by using the number of doses administered from the national database as the denominator. Relative risk (RR) and 95% confidence intervals (CI) were calculated using the national average as the reference. A P value of < 0.05 was considered as statistically significant.

Results

Overall reporting rates (1996–2005)

A total of 790 AEFI reports were received in the period 1996–2005 from a total of 7 292 640 vaccine doses administered to children aged < 6 years. The overall reporting rate for this period was therefore 10.8 per 100 000 doses administered or 33.7 per 100 000 population (based on the 2003 census figure for the population of Oman of 2 340 815).

Reporting rates by sex, age and region (1998–2005)

The data by sex, age and region were available as an electronic database only for the period 1998–2005 (Table 1). There were 657 reports over this period, a reporting rate of 10.7 per 100 000 doses administered.

A higher proportion of AEFI reports were among males than females (59.4% versus 40.6%) and the reporting rate per 100 000 doses administered was also significantly higher among males than females (12.6 versus 8.8) (RR = 1.1, 95% CI: 1.0–1.3, $P < 0.05$).

The highest proportion of adverse events was among children aged < 1 year (80.5%), compared with those aged 1–2 years (12.6 %) and > 2 years (6.8%). However, the reporting rate per 100 000 doses administered was significantly higher among those aged > 2 years (402.7) compared with the national average (10.7) (RR = 37.5, 95% CI: 22.7–50.7, $P < 0.05$) and compared with those aged < 1 year (10.9) and 1–2 years (6.6).

The distribution of AEFI reports by province (regions/governorates) for this period indicated that 4 regions had higher rates of adverse event reports per 100 000 doses administered compared with the national average: Dhahira (11.9), Dakhliyah (14.5), North Sharqiyah (41.3) and Musandam (69.6). However, only 3 regions (Dakhliyah, North Sharqiyah and Musandam) had statistically significant higher rates compared with the national average for this period (10.7) (Table 1).

Reporting rates by type of vaccine (1996–2005)

Figure 1 shows the number of reports for each vaccine for the full reporting period (1996–2005). BCG vaccine was responsible for the highest number of AEFI reports (326), both as a percentage of all 790 AEFI reports (41.3%) and as the rate per 100 00 doses of BCG administered (69.7). DTP was the second most common vaccine associated with AEFI reports (296); 37.5% of all reports or 15.3 per 100 00 doses of DTP administered. Pentavalent vaccine was the

Table 1 Frequency of reports of adverse events following immunization (AEFI) according to age, sex and reporting region, Oman (1998–2005)

Variable	AEFI reports		AEFI per 100 000 population[a]	No. of doses given	AEFI per 100 000 doses	RR (95% CI)
	No.	%				
Age (years)						
< 1	529	80.5	–	4 851 341	10.9	1.0 (0.09–0.13)
1–2	83	12.6	–	1 262 031	6.6	0.6 (0.4–0.7)
> 2	45	6.8	–	11 175	402.7	37.5 (29.6–54.2)*
Sex						
Male	390	59.4	29.7	3 104 094	12.6	1.1 (1.2– 1.7)*
Female	267	40.6	26.0	3 020 453	8.8	0.8 (0.6–0.8)
Region						
Musandam	43	6.6	151.5	61 758	69.6	6.4 (5.1–9.4)*
North Sharqiyah	187	28.5	133.5	452 698	41.3	3.8 (4.2–5.9)*
Dakhliyah	116	17.7	43.4	800 272	14.5	1.3 (1.2–1.7)*
Dhahira	57	8.7	27.5	478 469	11.9	1.1 (0.8–1.5)
Wustah	5	0.8	21.8	49 122	10.2	0.9 (0.4–2.3)
North Batinah	100	15.2	24.5	1 069 951	9.3	0.8 (0.7–1.1)
Dhofar	37	5.6	17.1	544 387	6.8	0.6 (0.4–0.8)
South Batinah	40	6.1	16.4	682 381	5.9	0.5 (0.4–0.7)
Muscat	61	9.1	9.7	1 476 834	4.1	0.4 (0.2–0.4)
South Sharqiyah	11	1.7	6.3	508 675	2.2	0.2 (0.1–0.3)
Total	657	100.0	28.1	6 124 547	10.7	Reference

[a]*Based on population of Oman (2003 census);*
**P < 0.05.*
– = data not available; RR = relative risk; CI = confidence interval.

Table 2 Frequency of reports of adverse events following immunization (AEFI) by type of adverse reaction: Oman (1996–2005)

Type of AEFI	AEFI reports		AEFI per 100 000 doses[a]
	No.	%	
Adenitis (BCG)	326	41.3	69.7
Local reactions	260	32.9	3.8
Systemic reactions	131	16.6	1.9
Injection abscess	73	9.2	1.1
Total	790	100.0	10.8

[a]*Number of doses given was 7 292 640 except for BCG adenitis (467 555).*
BCG = bacille Calmette–Guérin.

third most commonly associated with adverse events. There were 71 reports (21.7 per 100 000 doses administered) during the period when it was used (2003–05). There were 17 reports for MMR (3.6 per 100 000 doses administered), 14 for HBV (1.5 per 100 000 doses), 14 for measles (2.9 per 100 000 doses) and 4 for Hib (2.3 per 100 000 doses). OPV was not associated with any adverse events.

Reporting rates by type of adverse events (1996–2005)

Table 2 shows the number of AEFI reports by type of reaction for period 1996–2005. The most common adverse events were BCG adenitis, accounting for 41.3% (326/790) reports over the 10-year review period, followed by local reactions, such as severe pain and/or swelling, accounting for 32.9% (260/790). Injection abscess was reported in 9.2% of AEFI (73/790). The dose-related rates showed the same pattern: the 2 most commonly reported adverse reactions were BCG adenitis (69.7 per 100 000 BCG doses) and local reactions (3.6 per 100 000 doses of all vaccines). The more serious reactions were rarer: systemic reactions (1.8) and injection abscess (1.0). BCG adenitis was a significantly more common event after vaccination when compared with adverse events following other vaccines (RR = 10.3, 95% CI: 9.5–12.6, $P < 0.001$).

Types of events caused by vaccines

Although there were a high number of adverse events associated with pentavalent and DTP vaccine, a majority of them were local minor events (Table 3). For DTP, local reactions, systemic reactions and injection abscess occurred in 57.5%, 24.6% and 17.9% of reactions respectively. For the pentavalent vaccine 62.1% of the events were local reactions and 22.3% systemic reactions. Of reports for measles vaccine, 88.9% were systemic reactions such as fever and for MMR, 52.9% were systemic reactions.

The rate of BCG injection abscess was 1.2% or 0.8 per 100 000 doses administered.

There were no serious or systemic events reported for BCG, Hib or OPV vaccines. However, serious adverse events associated with measles/MMR (3.4%) included convulsions (1 case), febrile convulsions (1) and anaphylactic reactions (5) and with DTP were convulsions (8 cases), febrile convulsions (8), anaphylaxis (2) and unsteady gait (2).

Comparisons with other countries

Tables 4 and 5 compare the rates of AEFI reports in the USA, Canada and Australia with those found in the present study in Oman. The data show that the AEFI figures in Oman compare favourably with those in such developed countries.

Discussion

In Oman, the Ministry of Health policy dictates mandatory notification of all vaccine-related adverse events within 24 hours [*4*]. This paper provides an overview of all reported AEFI during the period 1996–2005. Of course not all these events were necessarily caused by vaccines. AEFI surveillance is complex, because the association between the reported exposure(s) and outcome(s) is temporal but not always causal. Inadequate or misleading information may have an adverse impact on the analysis and interpretation of AEFI surveillance data. Identification, detection, prevention and appropriate reporting of AEFI are therefore essential in ensuring the safety of vaccinations.

During 1996–2005, we received 790 reports out of over 7 million doses of vaccines that were administered. The overall rate for the reported vaccine types was 10.8 per 100 000 doses administered to children aged < 6 years, which is similar to the rates in USA (11.4 per 100 000 doses) [*7*] and Australia (11.8 per 100 000 doses for children aged < 7 years) [*8*]. Under-reporting could be a factor due to the passive reporting system [*9*]. Symptomatic local reactions and fever are reported to occur in about 10% of all vaccine recipients, except for DTP and TT boosters, in which they affect about 50% [*10*].

The number of adverse events in males was significantly higher than in females. Conversely, in other studies there were more events in females or only minimal differences between the sexes [*7,8,11*]. The highest proportion of AEFI reports was among children aged < 1 year (80.5%), which reflects the fact that this is the age group receiving the greatest numbers of vaccinations. These proportions were lower in the USA (18.1%) [*7*] and Canada (approximately 54%) in the age group < 1 year [*11*]. These variations in rates between countries may be largely due to different vaccines and regimens in

Table 3 Distribution of common adverse reactions reported per 100 000 doses of vaccines administered by type of reaction: Oman (1998–2005)

Type of vaccine	Total no. of AEFI reports	Systemic reactions			Local reactions			Injection abscess			Adenitis (BCG)		
		No.	%	Per 100 000 doses	No.	%	Per 100 000 doses	No.	%	Per 100 000 doses	No.	%	Per 100 000 doses
BCG[a]	326	0	0.0	0.0	0	0.0	0.0	4	1.2	0.8	322	98.8	68.9
DTP	296	59	19.9	3.8	138	46.6	9.0	43	14.5	2.8	–	–	–
Penta[b]	71	18	25.4	5.5	41	57.7	12.6	7	9.9	2.1	–	–	–
HBV	23	4	17.4	0.3	6	26.1	0.5	10	43.5	0.8	–	–	–
MMR	17	9	52.9	2.4	4	23.5	1.1	0	0.0	0.0	–	–	–
Measles	14	8	57.1	2.1	0	0.0	0.0	1	7.1	0.3	–	–	–
Hib[c]	4	0	0.0	0.0	4	0.5	2.3	0	0.0	0.0	–	–	–

The total does not correspond to the total no. of AEFI reports because some other events (minor and serious) are not included in the table.
[a]1996–2005.
[b]2003–2005.
[c]2002–2005.
BCG = bacille Calmette–Guérin; DTP = diphtheria–tetanus–pertussis; penta = DTP–Hib–HBV; HBV = hepatitis B virus; MMR = measles–mumps–rubella; Hib = Haemophilus influenzae type B; – = not applicable.

vogue. It was notable that the dose-related rates were much higher among children aged > 2 years compared with those aged < 1 and 1–2 years in our study.

Comparable to reports from the USA, Australia and Canada, the AEFI reporting rates varied among difference provinces in Oman [*7,8,11*]. Provincial variations exist for several reasons that may not be related to actual safety issues. These include variations in vaccination delivery (public or private), reporting rates, staff motivation and special vaccination programmes. It is worth noting that, for reasons unknown, in all these above-mentioned studies including our study, the least populated provinces had higher rates of AEFI. The significantly higher rates of AEFI in males, among children aged > 2 years and in some regions in Oman needs further investigation.

The most common adverse events were BCG adenitis (41.3%) followed by local reactions (32.9%). Local reactions such as fever, injection-site hypersensitivity or oedema, rash, injection-site oedema and vasodilatation were reported in 25.8%, 15.8%, 10.8%, 11.0%, and 10.8% of cases respectively in the Omani vaccine adverse event reporting system reports [*5*]. In Canada, the 3 most commonly reported adverse events were local reactions (32.4% of 3625), allergic reactions including rash (31.7%) and fever (23%) [*11*]. In contrast, the rate of serious adverse events in Oman was less (3.4%) compared with the data published from the USA in 2003 (14.2%) [*7*]. Two other studies found that nonserious reaction rates of 59% and 48% and serious reactions rates of 9% and 1% of all reactions respectively [*8,11*].

Injection abscess was reported in 9.2% of cases (1.0 per 100 000 doses administered). Local reactions are generally common in aluminium-containing vaccines. For BCG vaccine, an injection abscess may result from subcutaneous rather than intradermal delivery of vaccine [*3*]. The rate of BCG injection abscess was 0.8 per 100 000 doses administered. A higher rate of 43.6% for lymphadenitis and suppurative lymphadenitis (4 cases per 100 000) was reported from Poland [*12*]. In the West Indies it was concluded that it was related to the Pasteur strain used in the vaccine in Jamaica [*13*]. In South Africa, adverse events occurred in 3.1% of neonates, and a higher proportion of these presented with extranodal injection-site abscesses (41.0%) and lymphadenopathy (18.0%) compared with our results [*14*]. Similarly, in Sweden, regional lymphoglandular swellings (1.9 per 1000 vaccinated children) and/or abscesses (1.4 per 1000 vaccinated children) were most commonly reported [*15*].

After BCG, DTP was the second most common vaccine associated with adverse events. Local reactions, systemic reactions and injection abscess occurred in 46.6%, 19.9% and 14.5% of the cases respectively, which is within the expected rates of 50%–80% [*9*].

Pentavalent vaccine was the third most commonly associated with adverse events. There were 71 reports (21.7 per 100 000 doses administered) during the 2003–05 period. Approximately 58% of the events were local reactions followed by systemic reactions

Table 4 Comparison of reports of adverse events following immunization (AEFI) by type of vaccine in developed counties and in the present study in Oman

Vaccine	Oman 1996–2005[a] AEFI per 100 000 doses	USA 1991–2001[b] AEFI per 100 000 doses	Australia 2000–2002[c] AEFI per 100 000 doses	Oman 1996–2005[a] No. of AEFI reports received	Canada 1993–1997[d] No. of AEFI reports received
BCG	69.7	–	–	326	170
DTP	15.3	26.2	42.3	296	4 310
DTP–HBV	–	–	25.2	–	–
Hib	2.3	18.1	23.1	4	10 487
Hib–HBV	–	12.9	12.1	–	–
Measles	2.9	12.0	–	14	1 244
MMR	3.6	16.3	26.6	17	2 188
HBV	1.5	11.8	10.4	23	1 961
Penta	21.7	–	–	71	–

Sources: [a]Current study; [b][7]; [c][8]; [d][11].
USA = United States of America; BCG = bacille Calmette–Guérin; DTP = diphtheria–tetanus–pertussis; HBV = hepatitis B virus; Hib = Haemophilus influenzae type B; MMR = measles–mumps–rubella; penta = DTP–Hib–HBV; – = data not available.

(25%). In the Ghanaian safety study on pentavalent vaccine (September 2003 to December 2004), 28.3% of the children attended the study clinic with suspect AEFI including minor and/or unrelated events [*16*].

Measles and MMR were most commonly associated with systemic reactions such as fever than with local reactions. The MMR AEFI rate was 3.6 per 100 000 doses administered. Fever and rash are considered the most common reactions associated with MMR either in combination or used individually [*10*]. In the MMR campaign in Australia, the overall rate of adverse events was 5.24 per 100 000 doses administered [*17*].

Similar to a WHO report on vaccine safety, OPV was not associated with any adverse events [*9*]. Likewise serious adverse events are uncommon with HBV and Hib vaccines which in our study produced fewer local/systemic reactions than other vaccines [*9*]. Measles/MMR and DTP vaccines were associated with a few serious adverse events, i.e. convulsions, febrile convulsions, anaphylaxis and unsteady gait. In the WHO report convulsions accounted for 1 in 12 500 doses administered, hypotonic–hyporesponsive episodes 1 per 1750 doses, while anaphylaxis was rare (2 per 100 000 doses) [*9*].

The comparison of the Omani AEFI data with other studies around the world should be interpreted with prudence since the vaccines administered, immunization programmes, AEFI reporting

Table 5 Comparison of reports of adverse events following immunization (AEFI) by year in developed counties and the present study in Oman

Year	Oman [current study][a] Total no. of AEFI reports	Oman [current study][a] AEFI per 100 000 doses administered	Canada[b] AEFI per 100 000 net distribution doses	Australia AEFI per 100 000 doses distributed/administered
1996	52	8.8	33	–
1997	81	14.0	34	–
1998	68	8.8	27	–
1999	95	12.5	19	–
2000	105	14.0	26	
2001	82	11.0	28	19.8[c,g]
2002	86	10.0	23	
2003	72	8.5	16	14.6[d,h]
2004	73	10.6	17	11.8[e]
2005	76	11.0	–	11.0[f]

Sources: [a]Current study; [b][18]; [c][19]; [d][20]; [e][21]; [f][22].
[g]Period: 01/2000–09/2002; [h]10/2002–12/2003.

system and presentation of data may vary considerably.

Conclusion

It can be concluded that the AEFI surveillance in Oman is of a high standard as the reported rates are similar or below the international averages or expected rates. Surveillance of AEFI is always an integral component of a national immunization programme. As with any passive surveillance systems, underreporting is likely. Continued efforts on the part of immunization service providers and public health practitioners are essential to strengthen and sustain the quality of AEFI surveillance in Oman. In general, addressing vaccine safety issues effectively preserves the integrity of the immunization programme and avoids undue concerns in the community.

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References

1. Global status of immunization safety: a report based on the WHO/UNICEF Joint Reporting Form. *Weekly epidemiology record*, 2003, 78(7):44–7.
2. Mansoor O et al. *Immunization safety surveillance: Guidelines for managers of immunization programmes on reporting and investigating adverse events following immunization*. Manila, World Health Organization Regional Office for the Western Pacific, 1999.
3. *Surveillance of adverse events following immunization, field guide for managers of immunization programmes.* Geneva, World Health Organization, 1997.
4. *The milestones of EPI in Oman. Manual on expanded program on immunization*, 3rd ed. Muscat, Oman, Ministry of Health, 2003:1–62.
5. Ministry of Health, Oman. Hypersensitivity reactions reported with MR vaccine. *Community health and disease surveillance newsletter*, 1995, 4(3):7–8.
6. Ministry of Health, Oman. An unusual presentation of AEFI. *Community health and disease surveillance newsletter*, 2000, 9(1):10.
7. Centers for Disease Control and Prevention (CDC). Surveillance for Safety after Immunization: Vaccine Adverse Event Reporting System (VAERS)—United States, 1991–2001. *Morbidity and mortality weekly report*, 2003, 52(1):1–24.
8. Lawrence G et al. Surveillance of adverse events following immunization in Australia 2004. *Communicable diseases intelligence*, 2005, 29(3):248–62.
9. *Supplementary information on vaccine safety, Part 2: Background rates of adverse events following immunization*. Geneva, World Health Organization, 2000.
10. Stratton KR, Howe CJ, Johnston RB. *Research strategies for assessing adverse events associated with vaccines: a workshop summary*. Washington DC, National Academy Press, 1994.
11. National Report (interim) on Immunization Vaccine Safety Issues and Surveillance 1998. Reported adverse events temporarily associated with vaccine administration in Canada: 1993 to 1997 summary tables. *Journal of the Canadian Pediatric Society*, 1998, 4 (Suppl C).
12. Szczuka I. [Adverse event after BCG vaccination in Poland in the years 1994–1997]. *Pneumonologia i alergologia polska*, 1999, 67(5–6):208–16 [in Polish].
13. Praveen KN et al. Outbreak of Bacillus Calmette–Guerin associated lymphadenitis and abscesses in Jamaican children. *Pediatric infectious disease journal*, 1990, 9(12):890–3.
14. Prakash MJ et al. Safety of the intra-dermal Copenhagen 1331 BCG vaccine in neonates in Durban, South Africa. *Bulletin of World Health Organization*, 2001, 79(4):337–43.
15. Romanus V et al. Adverse reactions in healthy and immunocompromised children under six years of age vaccinated with the Danish BCG vaccine, strain Copenhagen 1331: implications for the vaccination policy in Sweden. *Acta paediatrica*, 1993, 82(12):1043–52.
16. Dodoo AN et al. Safety monitoring of a new pentavalent vaccine in the expanded programme on immunisation in Ghana. *Drug safety*, 2007, 30(4):347–56.
17. D'Souza RM et al Adverse events following immunisation associated with the 1998 Australian Measles Control Campaign. *Communicable diseases intelligence*, 2000, 24(2):27–33.
18. Canadian national report on immunization. *Canada communicable disease report*, 2006, 32(Suppl. 3):1–44.
19. Lawrence G et al. Adverse events following immunisation: Australia 2000–2002. *Communicable diseases intelligence*, 2003, 27:307–23.
20. Lawrence G et al. Surveillance of adverse events following immunisation: Australia 2002–2003. *Communicable diseases intelligence*, 2004, 28:324–38.
21. Lawrence G et al. Surveillance of adverse events following immunization in Australia 2004. *Communicable diseases intelligence*, 2005, 29:248–62.
22. Lawrence G et al. Surveillance of adverse events following immunisation: Australia 2005. *Communicable diseases intelligence*, 2006, 30:319–33.