



INFECTIOUS DISEASES IN OMAN: A REVIEW AND PROGRESS TOWARDS ELIMINATION AND ERADICATION

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ABSTRACT Over years great strides have been made in Oman towards control, elimination and eradication of major communicable diseases. This calls for a detailed review and study of the successful models in countries which have managed to these achievements. This is evident from the fact that the incidence and prevalence of many of the diseases have continued to remain low in the country including vaccine preventable diseases, brucellosis, leprosy, malaria, rabies, tuberculosis, trachoma, and dracunculiasis, in addition to prevention of mother-to-child transmission of HIV. A particularly noteworthy behind the success was strong local political will, extended programme of immunization, surveillance network, inter-sectoral cooperative efforts for surveillance and well trained human resources as a result Oman have managed to reach and maintain remarkable success in evolving policies for control, elimination and eradication.

KEYWORDS :Infectious diseases; vaccine preventable diseases; VPDs; Brucellosis; Leprosy; Prevention of mother-to-child transmission (PMTCT); Malaria; Rabies; Tuberculosis; Trachoma; Dracunculiasis; Oman; control; elimination; eradication

Introduction

Oman is one of the twenty-two countries in the World Health Organization (WHO) Eastern Mediterranean Region (EMR). It is located in the south-eastern corner of the Arabian Peninsula with a coast that extends 3,165 kilometres from the Strait of Hormuz. Oman's borders include Yemen to the south, and the Kingdom of Saudi Arabia and United Arab Emirates to the west.

The population was 4,159,102 in 2015, with immigrant workers and their families, mostly from South and Southeast Asia, accounting for nearly 44%. Children under 5 years of age comprise 9.5 % of the population and those below 15 years of age comprise only 22% [1, 2].

Oman has been enjoying a stable political, economic, social system and the resultant health system development for almost five decades. This has resulted in near universal access to health care and remarkable changes in its health status as evidenced by the health status indicators and its achievement of all the health-related Millennium Development Goals (MDGs) i.e. average life expectancy in 2015 increase to 76.4 years for both sexes at birth, and maternal mortality dropped from 27.3 in 1990 to 11 per 100,000 live births in 2015 [1].

There has been a dramatic decline in mortality indicators. As of 2015, the infant mortality was 9.5/1000 live births, under five mortality was 11.4 per 1000 live births and maternal mortality rate was 17.5 per 100,000 live births. This can be attributed to the extensive population coverage with primary health cares (PHCs) as over 98% of the population have access to primary health care services, the nearly 99.2% have antenatal care coverage (at least one visit during pregnancy), in addition to immunization coverage levels which have increased substantially from 10% in 1981 to over 95% in 2015 [1].

Oman has also achieved remarkable success in evolving policies for control, elimination and eradication of major communicable diseases. These include the expanded program of immunization (EPI) for the prevention of vaccine preventable diseases, which was initiated in 1981; the malaria eradication program initiated in 1975 and other health programs directed to health problems such as tuberculosis, diarrheal diseases in children and acute respiratory infections in children [1].

This report provides an overview of some of communicable diseases and describes what is known about the epidemiology and the major achievements in their control, including the progress towards their elimination and eradication, as well as the way forward.

Methodology

Data on infectious diseases epidemiology have been drawn from: a) the Community Health and Diseases Surveillance Newsletters 1992-

2011; b) the annual health statistical reports 1995-2015[1]; c) the Ministry of Health (MOH) annual progress reports (2000-2012); d) the Ministry of Health Oman, "Health vision 2050" [3]; and e) the manuals for the national communicable diseases. The incidence and prevalence rates and TB projection rate have been calculated. Data analysis was conducted by using Epi-Info 6 software with p value < 0.05 was taken as a cut off point for significance of the association, using Chi-Square test.

National Surveillance System

The national communicable disease surveillance was formally launched in March 1991 to be in conformity with the 'communicable diseases law' issued by the royal and ministerial decrees. The department of communicable disease control (DCDC) functions as the apex body. The surveillance system ensures the collection and use of appropriate and timely data for dealing with the target priority diseases including emerging and re-emerging infections. The priority communicable diseases are grouped into 'A', 'B' and 'C' based on the urgency of reporting and the response. The grouping of the notifiable communicable diseases was completely revised in 2005 to accommodate their status of control/elimination, trends and changing priorities. More emphasis was placed on syndrome reporting that helps to prevent the diagnostic delays and encourages a rapid response.

Vaccine preventable diseases (VPDs)

The Expanded Program on Immunization (EPI) was launched in 1981. Since then, numerous efforts have been made to ensure the expansion of EPI at the grass roots level [4, 5]. EPI has been integrated into the Primary Health Care (PHC) services provided by the Ministry of Health (MOH). The immunization coverage levels have increased substantially from 10% in 1981 to over 95% in 1995 [4] and the near 98% coverage among eligible persons that has been maintained at national and provincial levels has resulted in a significant impact on the incidence of vaccine preventable diseases. The administrative coverage has been confirmed by periodic validation of the vaccination coverage data using data quality self-assessment (DQS) every 3 years and coverage evaluation surveys every 5 years, the last one was conducted in 2008 and the results were consistent with the administrative coverage in the country [6].

The high immunization coverage can be attributed to the political commitment, in addition to the successful policies of single administrative control for EPI, the strong supply chain management, the integration of EPI services into the 'Primary Health Care', the decentralization and self-sustainable programme, the highly dedicated staff for EPI unit, the built-in efficient internal supervisory and monitoring system, and the regular external reviews by WHO/ UNICEF [5].

Achievements

Polio: In 1988, Oman achieved nearly 90% coverage of oral polio vaccine 3 (OPV3), and since 1994-95, 99% coverage has been reported nationally and provincially [Figure 1]. The last outbreak of poliomyelitis in Oman was in 1988-89 due to Type-1 poliovirus resulting in 118 cases. A strong and dedicated acute flaccid paralysis (AFP) surveillance was implemented in 1993 and linked with immediate action and control measures. As a part of this surveillance system, sentinel sites were initiated with weekly zero reporting. Since then the AFP surveillance rate has always been above the recommended rate of 2/100,000 among ≤ 15 years. In addition, national immunization day campaigns to ensure high coverage and quality of polio vaccinations were organized from 1995-1999. The last two cases reported in 2005 were imported type-1 wild poliovirus.

Diphtheria: The last case of diphtheria in Oman was reported in 1992. Diphtheria elimination has been maintained due to near 99% coverage with diphtheria, tetanus and pertussis 3 (DTP3) in EPI [Figure 2].

Pertussis: Oman has made progress towards pertussis control goals by implementing two main strategies: firstly, achieving and sustaining high immunization coverage and maintaining high population immunity, and secondly, developing efficient surveillance system, and hence low pertussis incidence.

The first strategy of sustaining high immunization coverage has been achieved through high routine immunization coverage (DTP3), reaching $\geq 97\%$ (recommended ≥ 90 [7]) coverage nationally and provincially. The second strategy, developing case-based surveillance for pertussis, was implemented. Over the last decade, Oman has achieved all the targeted pertussis surveillance performance indicators.

The introduction of infant vaccination programmes in 1981 was associated with a steep decline in the number of pertussis cases [Figure 3]. Despite maintaining high DTP3 and booster doses immunization coverage rate ($\geq 97\%$) among preschool-aged children, prevention directed at treatment of pertussis cases to prevent further spread of disease, and use of antimicrobial prophylaxis in contacts of pertussis cases, the control of pertussis has been a challenge in Oman, and had experienced an increased periodic outbreaks of pertussis. The outbreak and incidence showed seasonal variation within years and epidemic cycles over multiple years with peaks occurring at 3 to 5 year intervals with major outbreaks occurred in 2008 and 2013 as the number of susceptible persons in the population increases.

Due to the difficulties associated with the laboratory confirmation of pertussis the national guideline informed only outbreaks or clusters were investigated and the majority of the sporadic cases reported were clinical. Hence, in January 1998, DTP was rescheduled in the EPI to 6 weeks, 3 months and 5 months. In January 2008, the DTP was rescheduled to be provided at 2 months, 4 months, 6 months and booster at 18 months.

In the vaccine era, pertussis cases were observed almost 85% in children aged < 12 months (rate of 185 per 100,000 population); notably the incidence is highest among age < 2 months followed by 2 to 4 months which eluded that these infants aren't protected. Therefore, there is a need to introduce Tdap among pregnant women in order to reduce the cases among < 12 months [8].

Tetanus: Neonatal tetanus (NNT) elimination target based on World Health Organization (WHO) elimination criterion (i.e. ≤ 1 case per 1000 live births per district) has been achieved since 1992 (Figure 4) and the last case was notified in 1995. With the high coverage of routine and maternal tetanus toxoid 5 (TT5), the elimination is sustained in the forthcoming years. Oman is still reporting a small number of non-NNT among non-nationals; therefore, there is a need to continue maintaining a high coverage rate [Figure 4].

Hepatitis B: Hepatitis B vaccination was introduced into EPI schedule from 1st August 1990 and over 97% coverage of Hepatitis B- 3 doses (HBV3) nationally and provincially was achieved from the outset [Figure 5]. Initially three doses were given at birth, at 40 days and at 7 months. Later in 2008, it was reschedule to be at birth, 2 months and 6 months. Hepatitis cases dropped from 368 cases (incidence rate 19/100,000 population) in 1992 to 15 cases (incidence rate 0.4/100,000 population) in 2015, $p < 0.000$ Chi-Square test [Table 1].

Catch-up school campaigns were conducted to target the unvaccinated adolescents (2001 to 2004). Post-exposure prophylaxis using hepatitis B vaccine and/or hepatitis B immune globulin (HBIG) was used after percutaneous or mucous membrane exposures to blood that contain HBs Ag such as needle-stick injury. The first phase of routine health care workers (HCW) screening and vaccination was launched in 2011. The Hepatitis B programme to adopt the elimination goal.

Measles & Rubella: Measles vaccine was introduced in early eighties at 9 months and the coverage has been above 90% since 1989 [Figure 6]. Rubella vaccine was introduced along with second dose of measles at 15 months as measles-rubella (MR) in 1994. Since then, rubella coverage has been above 95%. [Figure 6]. The priority status for measles and rubella was upgraded from group B to A in 1993. A mass catch-up campaign with MR vaccine was conducted in March 1994 following the last nationwide concurrent outbreak of measles and rubella in 1992-93. The target population was 15 months to 18 years. A single dose of MR was given irrespective of the previous immunization status and in this campaign and over 94% coverage was achieved [9]. The measles cases dropped from 1834 cases (incidence rate 97/100,000 population) in 1992 to zero cases in 2015, $p < 0.000$ Chi-Square test. Similarly, rubella cases dropped from 211 cases (incidence rate 11/100,000 population) in 1992 to zero cases in 2015, $p < 0.000$ Chi-Square test [Table 1].

Syndromic fever and rash surveillance was launched in April 1996. All fever-rash illness cases were subjected to serological test for measles as well as rubella (IgM ELISA). So far, Oman had successfully achieved measles/rubella elimination standards ("0" endemic cases) based on WHO elimination criteria and are had reported no endemic measles and rubella virus transmission for the last three years.

Congenital Rubella Syndrome (CRS): Widespread use of rubella vaccine and a first dose coverage of more than 95% led to a dramatic decline in the incidence of CRS [Figure 7]. Additionally, since 2001, post-partum rubella vaccination of susceptible mothers has been a national priority resulting in achievement of above 99% coverage. Oman implemented CRS surveillance in 2004, and in 2005, established a policy to eliminate rubella. Rubella elimination was defined as the absence of endemic rubella transmission and no CRS cases associated with importation into Oman for ≥ 12 months. Since 2000, only one case of congenital rubella infection was locally transmitted and two CRS cases were imported [Figure 7] [10, 11].

Mumps: The mumps vaccine was introduced into the EPI programme in October 1997 as measles, mumps and rubella (MMR). The coverage has been $> 99\%$ nationally and at governorate (provinces) since its introduction. As shown in [Figure 8], there is a continuous decline in its incidence over the years. Mumps cases dropped from 10,655 cases (incidence rate 563/100,000 population) in 1992 to 588 cases (incidence rate 14/100,000 population) in 2015, $p < 0.000$ Chi-Square test [Table 1].

Hib meningitis: Haemophilus influenzae type b meningitis was included under Group 'B' notifiable disease in July 1992 and to be reported within 7 days. Hib vaccine has been introduced into the EPI schedule since October 2001. It was replaced with 'Penta' vaccine (DTP-Hib-HepB) in July 2003. In 2005, the disease was shifted to Group A category. Since 2000, when about 20 cases of Hib meningitis were reported, a steady decline in Hib meningitis has been seen in Oman, with only one case reported in 2010 and no case reported in the subsequent years.

Prevention of mother-to-child transmission (PMTCT) of HIV: The transmission of HIV from HIV-infected mother to her child is the most common route of HIV transmission in children [12]. In July 2009, HIV screening among pregnant women was introduced. A national HIV screening and counselling for pregnant women attending antenatal care (ANC) was implemented as a component of the package of care at primary health care. Upon confirmation of a positive test, antiretroviral therapy (ART) is provided.

Cumulatively, 424,077 pregnant women have been registered in the ANC clinics across the country since July 2009 to 2014, with high levels of ANC coverage, where $> 95\%$ of pregnant woman had at least one ANC clinic visit. Of these, 421,125 (98%) pregnant woman had received HIV testing and pre and post counselling [Table 2].

The annual percentage of HIV testing was 98% in 2009 (July-December), 98% in 2010, 97% in 2011, 90% in 2012, 98% in 2013, 98% in 2014. Of the total pregnant woman screened, 90 HIV positive cases were identified suggesting a cumulative HIV sero-prevalence among pregnant women of 0.02%. The annual distribution of the cases was 5 in 2009 (July-December), 21 in 2010, 16 in 2011, 17 in 2012, 22 in 2013, and 9 in 2014 ($p < 0.001$), [Table 2]. Among the newly diagnosed of HIV-positive pregnant woman, 85 (94%) were within the age group 20-49 years, with a median age of 35 years. During to the same period, 31 infants were HIV positive, born to HIV-positive mothers; the annual distribution of the cases was 3 in 2009 (July-December), 5 in 2010, 10 in 2011, 6 in 2012, 4 in 2013, and 3 in 2014. The percentage of mother-to-child transmission of HIV were 60, 23, 63, 35, 18, and 33 respectively ($p < 0.001$), and the annual average is 39%. No information was collected on segregation into breastfeeding and non-breastfeeding among the HIV children born to HIV-positive mothers. The rates of infection due to MTCT per 100,000 live births were 11, 9, 17, 10, 6 and 4 respectively and the annual average is 10 per 100,000 live births [Table 2]. ART was used for HIV-positive pregnant women as well as prophylaxis is given to infant born to HIV-positive mothers, however no information is published on uptake, completion of prophylaxis or causes of not receiving/refusing of use ART.

The introduction of HIV testing and counselling services was very successful; however mother-to-child HIV transmission rate still below the target, therefore, the contributing barriers need to be identified and managed.

Brucellosis: Brucellosis is considered one of the major zoonotic infections worldwide [13]. This bacterial disease causes severely disabling illness in human health [14] and extensive economic losses in terms of animal production [15].

In Oman, human brucellosis is an important zoonotic disease and is significantly prevalent in southern of the country viz. Dhofar Governorate (province) [16], where livestock population is high. A serologic survey of domestic animals in Dhofar Governorate was conducted in 1985-86 [17] and revealed that *Brucella* sero-positivity were primarily among camels 3.6%, cattle 2.9%, sheep 1.6% and goats 0.9%, therefore it was assumed that camels become infected from goats and that *Brucella* Melitensis biovar 1 organisms are excreted in the milk of camels with subsequent human infections.

Brucellosis cases reported 371 cases (incidence rate 20/100,000 population) in 1992 and 379 cases (incidence rate 9/100,000 population) in 2015, $p < 0.06$ Chi-Square test [Table 1]. Dhofar Governorate constitutes 388.092 (9.7%) of the country's population [13] and reports more than 95% of total brucellosis cases nationally. Annual national incidence has observed an upward trend since 2009, the median cases was 137 (range 79- 235 cases), the annual rate of increase is 27. Between 2009-2015 [Figure 9], the disease was mostly prevalent in the mountainous and green areas, where Salalah Wilayat (district) has the highest (39%) of the cases with (47%) in children under the age of 9 years, wherever it was detected in children; ingestion of raw milk and milk products were responsible for transmitting the disease in 63% of the cases [18], while 83% had history of direct contact with animals, mainly cattle [19].

In 2000, the Ministries of health and agriculture adopted control strategies including vaccination of livestock population, strong human surveillance system and awareness among the community against high-risk behaviour with ultimate goal to eliminate the brucellosis among livestock. As of 2003 onward, livestock population is being immunized by Ministry of Agriculture against brucellosis with the long term commitment (12 years) by the Ministry of Agriculture in Dhofar governorate (province). As the most important source of brucellosis isolation was from the milk, hence more efforts were carried out to increase prevention through behaviour modification among the community regarding drinking raw milk and proper handling of animal deliveries and aborted animal foetus by the individuals, as well as continuing the vaccination of susceptible animals against brucellosis. Oman is at a critical juncture regarding brucellosis control and ultimately elimination in livestock. The programme needs to review its national targets and strategies, and to develop a research agenda to identify the cost effectiveness of management of brucellosis and conduct studies to identify the source of the disease.

Chlamydial Infection (Trachoma): The trachoma control program was launched in 1975 in Oman and initially was named the Prevention of Blindness program in 1983, and then as the "Eye health care program" in 1990 which was comprehensive and integrated into the primary health care (PHC), with the main focus was trachoma control.

At the time when trachoma was endemic and spread across the country, the disease was distributed unevenly mainly in northern and central parts of the country. So the eye health care program divided the country into 3 areas namely, trachoma endemic areas of recent past (3 governorates), trachoma areas (other governorates) of northern and central Oman and low trachoma endemic governorates (Muscat and Dhofar) [20].

The eye health care program had ten years goal for eliminating trachoma nationwide, to achieve these goals, regular surveys, screening of all school children, home visits of all children with active trachoma, and screening of family members was implemented. Extensive health education campaigns were also conducted in schools and health institutions and as a result trachoma control were achieved in the year 2000 [21].

Due to implementation of active surveillance and the individual supervised treatment for active trachoma, a significant decline in number of cases of active trachoma was noticed and a survey conducted in 2004 found that the active infection of trachoma was consistently less than 1% among school children and in preschool children [21].

Oman had implemented all the four Ultimate Intervention Goals (UIGs) which are a set of indicators finalized by global elimination of trachoma 2020 in 2006 and had the capability to monitor the progress and identify any increase in the incidence of active trachoma.

In 2012, Oman became the first country to be recognized as having eliminated trachoma as a public health problem [22, 23]. Oman's achievements in combating blindness caused by trachoma is sustained by continuing the active surveillance and trachoma control being integrated in vision 2020 program [Figure 10] [20].

Malaria: in 1991, the Ministry of health (MOH) adopted a strategic goal to reduce the incidence of malaria as a public health problem aiming at interruption of malaria transmission and elimination of the reservoir of infection. The programme was first launched in North and South Al-Sharqiya governorates (provinces) as a pilot project. The strategies applied were: vector control, mainly larviciding, early case detection and prompt radical treatment. After the successful achievements of the pilot project in reducing the number of malaria cases, it was extended to other governorates in phases, with the goal of reaching to annual parasite incidence (API) of 1/1000 population by the year 2000.

Subsequent to the remarkable drop in the number of malaria cases in 1994, investigation and epidemiological classification of all the cases was initiated [Figure 11] [24]. The national data analysis showed that the main sources of importation of malaria to Oman were East Africa and the Indian subcontinent; accordingly, appropriate strategies were implemented including distribution of the prophylactic drugs for the travelers and screening upon arrival of passengers from Africa. In addition, private health institutes were involved in the early case detection strategy to cover the cases coming from the Indian subcontinent [25].

Interruption of malaria transmission was achieved in 2004 and maintained until September 2007 when a focus of local transmission was detected in Dakhiliya governorate. In 2008 another outbreak of local transmission occurred in North Batinah governorate. In 2009 no local transmission occurred. However, due to the high receptivity and increased vulnerability of the country and due to the increase in the number of imported cases, secondary cases were detected in North Sharqiya governorate in 2010 and in North Sharqiya & Al Dakhiliya governorates (provinces) in 2011 which were controlled immediately [25].

In 2012, a total of 2051 cases were recorded. Out of them, 2035 (99%) were imported, mainly from the Indian-subcontinent countries. In 2012, 1940 (95%) of the diagnosed cases were *Plasmodium vivax* and 4% of the cases were *P. falciparum*. In 2013, foci of local transmission

were detected in AL Dakhliya North Batinah and South Sharqiyah governorates. The country reported 984 imported and 15 introduced (locally transmitted *P. vivax* case) and zero indigenous cases in 2014, while in 2015 a total of 822 cases were recorded majority 85.2% were *P. Vivax* and 14.3% were *P. Falciparum*[24,25].

Oman was one of the seven countries which achieved more than 75% decrease in the incidence of microscopically confirmed cases between 2000 and 2014[26] and in 2014, Oman was among 16 countries reported zero indigenous cases of the disease [27]. The main challenges faced Oman to achieving malaria eradication /elimination program (i.e. preventing re-establishment of malaria transmission and maintaining the incidence indigenous malaria cases at zero level) are, a) the increase in developmental projects which have led to the increased in the influx of imported malaria cases through the labor force from malaria endemic countries, and b) the worsening malaria situation in the source countries, both of which have increased the vulnerability of the country.

There is need for a national web based comprehensive malaria data base; establishment of standard insectarium at the central level and monitoring of resistance to insecticides [28].

Leprosy: Globally, the leprosy burden was significantly reduced since the introduction of multi-drug therapy (MDT). Over 16 million people affected by leprosy have been diagnosed, treated and cured worldwide [29]. In Oman, the national leprosy control program (NTLCP) was launched in 1981, and offered treatment and supportive services to handle all new cases. Multi drug therapy (MDT) was implemented in 1992 with almost above 95% coverage; surveillance system for early recognition and management of leprosy is being implemented. WHO defined "elimination" as a prevalence rate of less than 1 case per 10,000 inhabitants by 2000[30]. The leprosy prevalence rate significantly declined from 1.64 to 0.09 per 10,000 population during the period 1992 to 2015, ($p < 0.0001$, Chi-square =136.06). The incidence of leprosy has declined from 35 to 40 cases (rate ranged 1.64 to 0.52 per 10,000 population) during 1992 to 1999, and further declined sharply to 4 from 10 cases (rate ranged 0.11 to 0.09 per 10,000 population) between 2000 to 2015 [Figure 12]. Based on WHO definition (rate < 1/10,000 population), Oman achieved elimination target since 1996 and maintained it thereafter. Oman has met the elimination goals and made great strides towards becoming a leprosy-free country.

Tuberculosis: Tuberculosis (TB) is a major global public health problem that affects millions of people around the globe, predominantly in low- and middle-income countries. Further, TB is also a persistent health threat in high-income countries, especially among the poorest [31].

In May 2014, the World Health Assembly adopted WHO's post-2015 global TB strategy, and has developed a global TB strategy with a perspective beyond 2015 with the ambitious targets of reducing the numbers of deaths due to TB by 95% and the incidence rate of TB by 90% by 2035 as compared to 2015 [32].

WHO with the European Respiratory Society and other partners adopted the global framework for TB elimination, which represents an adaptation of the new global TB strategy to low-incidence settings. The framework outlines eight priority action areas that can be considered the key interventions for accelerating progress towards pre-elimination and, ultimately, elimination of TB. The new strategy includes a target of reducing the global incidence of TB by 90% between 2015 and 2035 [23].

"Low-incidence countries" are defined as those with a TB notification rate of < 100 TB cases (all forms) per 100,000 population and year. "Pre-elimination" is defined as < 10 notified TB cases (all forms) per million population per year. "Elimination of TB as a public health problem" is defined as < 1 notified TB case (all forms) per million population per year [32].

National Tuberculosis programme (NTP) was launched in 1981. The program is being implemented through a system of reporting, diagnosis, treatment, contact screening and latent TB management. National policies and guidelines are issued as standard operating procedures manual. The data are analysed and monitored. Governorate monitoring visits are conducted for review of the program activities.

The programme has been integrated into Primary Health Care and services to achieve the highest standard of care in management of TB cases.

Between 2008 and 2014, the TB burden trends ranged from 12 to 7 per 100,000 population. The TB notifications showed that Oman had a downward trend incidence between 2012 and 2013; [Figure 13] [33]. Based on recent projections and taking into account the trend of the last 3 years [Table 2] in Oman, the TB rates are already getting closer to pre-elimination levels (<10 per 100,000). Furthermore, with the current TB rate of decline, Oman would only reach pre-elimination by 2036. This would require an average annual rate of decrease from 2015 onwards to be about 12–18%, with a mean of 16%. The average annual rate of decrease required to achieve elimination in 2050 is 7–11%.

Oman is required to accelerate the progress towards TB Elimination by strengthening TB surveillance and control services in private health facilities, undertaking screening for active TB and LTBI among TB contacts and selected high-risk groups, and provide appropriate prioritization of other screening activities on the basis of mapping of risk groups and assessing benefits, risks and costs.

Rabies: Prior to 1990, Oman was considered free from rabies as no human cases were reported. The reservoir for the infection is Red Fox (*Vulpes vulpes*). The first case reported was boy developed rabies after a fox bite in the village of Yankul, Dhahira governorate. Since 1990, 9 cases of rabies were notified and in 2003, a pregnant woman from Dhofar governorate was reported and the last case was in August 2016 from a non-national, imported cases from Bangladesh reported from Muscat governorate. On regular bases, there is an exchange of information with Ministry of Agriculture; consequently, early warning system is in place for any surge of rabies among animal population that might lead to increased risk of exposure among humans. As it is proven that rabies exists epizootically in Oman, there is a need to set a control program in animal population viz. vaccination, however due to the hot weather this intervention would be difficult to implement.

Filariasis: Lymphatic filariasis (LF) is targeted for global elimination as a public health problem by 2020, with an aim to stop the spread of infection and alleviate suffering [34].

In order to verify the status of LF in Oman, immunochromatographic card test surveys were carried out among school students to assess the presence of circulating *Wuchereria bancrofti* antigenaemia in South Batinah and Dhofar governorates (provinces), and it was found that the prevalence of filarial antigenaemia was zero. The negative finding for LF antigenaemia suggests lack of LF transmission in the surveyed areas. Based on this finding Oman has been classified by WHO as non-endemic country with no evidence of indigenous LF transmission [35]. Post-validation surveillance will be needed to ensure elimination targets are sustained.

Dracunculiasis: On the recommendation of the International Commission for the Certification of Dracunculiasis Eradication (ICCE), Oman was certified free of Dracunculiasis in 19th November 1997 [36].

In conclusion, Oman has made tremendous progress towards elimination and eradication of many diseases, namely vaccine preventable diseases, tropical diseases, mother-to-child transmission of HIV, Brucellosis, Malaria, Leprosy, Rabies, Tuberculosis, Trachoma, Filariasis and Dracunculiasis. Strong political will, sensitive surveillance, and inter-sectoral cooperation among different stakeholders are needed for maintaining these achievements.

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Conflict of interest

The authors declare no conflict of interest

Figure 1. Polio cases and oral polio vaccine (OPV) coverage (%), Oman, 1975-2015

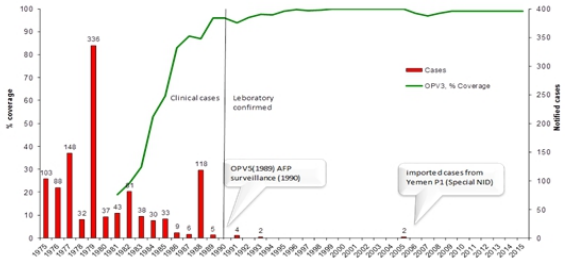


Figure 2. Diphtheria cases and diphtheria, tetanus and pertussis vaccine (DTP3) coverage (%), Oman, 1975-2015

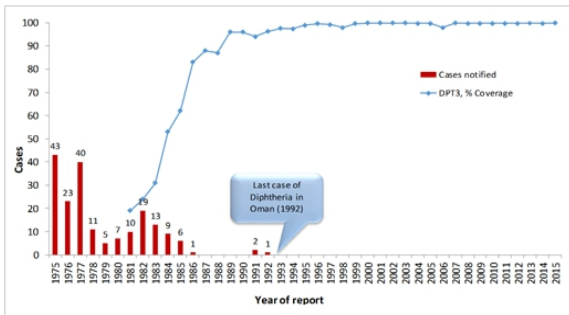


Figure 3. Number of reported pertussis cases, incidence rate of pertussis and diphtheria, tetanus and pertussis vaccine 3(DTP3) coverage (%) by year of report, Oman, 1981-2015

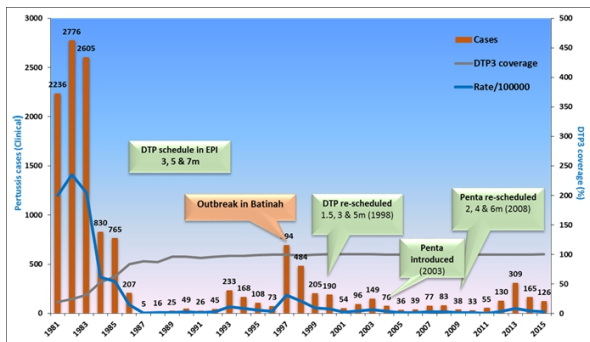


Figure 4. Neonatal (NNT) and non-neonatal tetanus (Non-NNT) cases by year of report, Oman, 1983-2015

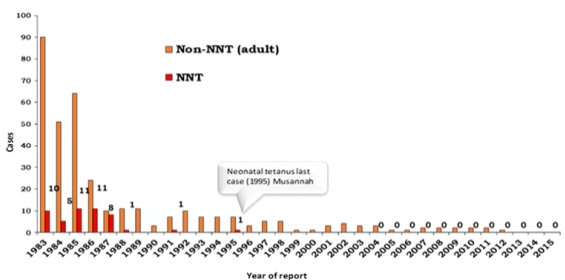


Figure 5. Hepatitis B cases and Hepatitis B vaccine (HBV3) coverage (%), Oman, 1991-2015

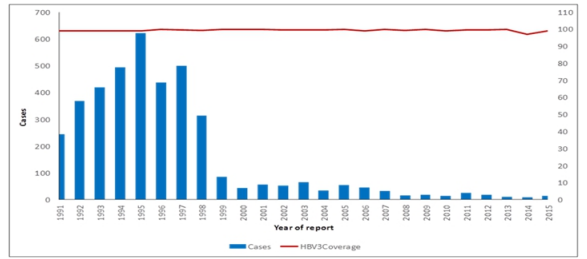


Figure 6. Measles cases and measles containing vaccine (MCV) coverage (%), Oman, 1975-2015

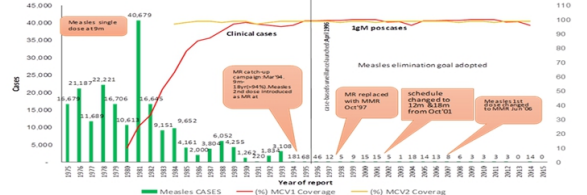


Figure 7. Rubella and congenital rubella syndrome (CRS) cases and rubella containing vaccine (RCV) coverage (%), Oman, 1985-2015

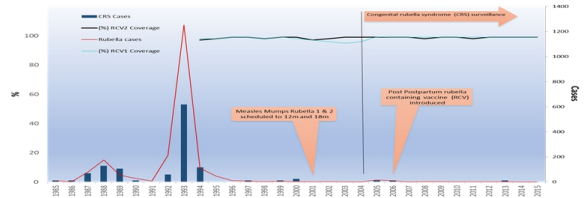


Figure 8. Mumps cases and mumps containing vaccine 2 by year of report, Oman, 1991-2015

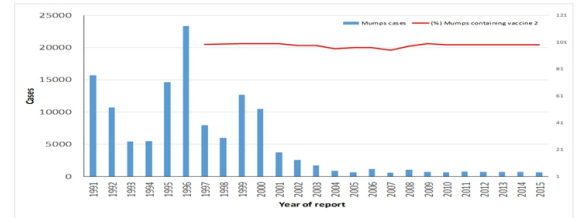


Figure 9. Brucellosis cases by year of report, Oman, 2001-2015

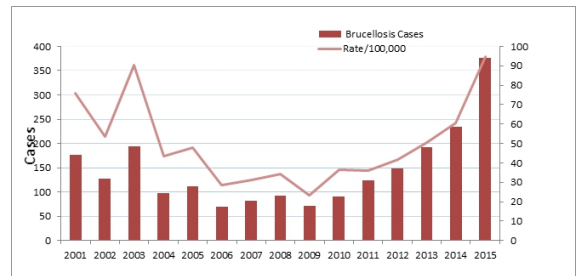


Figure 10. Chlamydia rates by year of report, Oman, 1993-2014

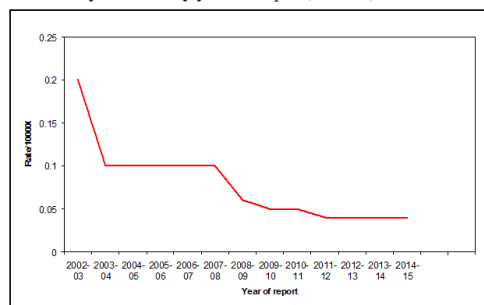


Figure 11. Malaria cases and incidence by year of report, Oman, 2005 - 2015

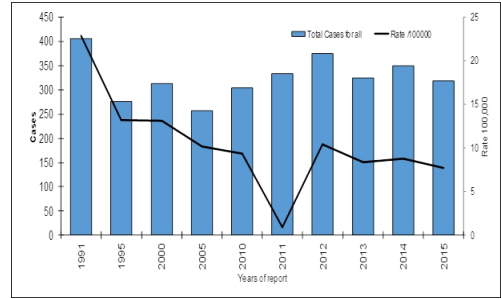
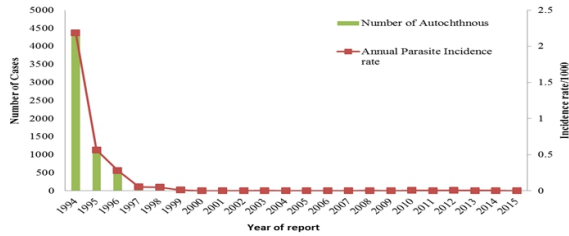


Figure 12. Leprosy cases and rate 10,000 population by year of report, Oman, 1992-2015

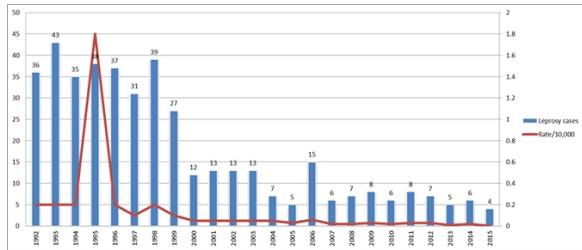


Figure 13. Trends in TB notifications and incidence, Oman (OMN) and some countries 1990-2014

Table 1. Changes in gross incidences of important communicable diseases per 100,000 populations, Oman, 1991-2015

Disease	Incidence in 1992 (*)	Incidence in 2015 (*)	P value
Measles	1834 (97)	0	<0.000
Rubella	211 (11)	0	<0.001
Mumps	10,655 (563)	588 (14)	<0.000
Viral hepatitis B (HBsAg positive)	368 (19)	15 (0.4)	<0.000
Brucellosis	371 (20)	379 (9)	<0.061
Leprosy **	36 (0.2)	4 (0.01)	1
Malaria	14,827 (784)	822 (2)	<0.000
Trachoma	10,142 (535)	0	<0.000
Tuberculosis (all types)	432 (23)	319 (7.6)	<0.011

Table 1: (*) Incidence rates per 100, 000 population (**) Incidence rate per 10,000 population

Table 2. Coverage of prevention of mother-to-child transmission, Oman, 2009 (July-December), 2014.

	Calculation	WHO elimination target	Year of report					P value	
			Jul-Dec 2009 No (%)	2010 No (%)	2011 No (%)	2012 No (%)	2013 No (%)		2014 No (%)
		-							-
Registered pregnant women at ANC *coverage at least one ANC clinic visit		≥95%	34400 (>98)*	67480 (>98)*	72783 (>98)*	78934 (>98)*	78934 (>98)*	87658 (>98)*	
Coverage of woman received HIV testing		≥95%	33822 (98)	67131 (98)	72321 (97)	71354 (90)	78934 (98)	87658 (98)	0.998
Pregnant women testing HIV positive (a)		-	5	21	16	17	22	9	<0.001
HIV live infants born to HIV-positive pregnant women (b)		-	6 cases (all year) 3 cases(July-Dec)	5	10	6	4	3	0.062
Alive births (c)		-	27,975	55,712	57,323	61,549	66,772	68,293	-
Percentage of HIV new born infants born to HIV infected mothers	b/a*100	Transmission rate of either <5% in breastfeeding populations or <2% of non-breastfeeding populations	60	23	63	35	18	33	<0.001
New HIV infections due to MTCT of HIV per 100,000 live births	b/c*100,000	≤ 50 new-born infection per 100,000 live births	11	9	17	10	6	4	0.998

Table 3. TB incidence rates, trends and projections, Oman

	Population (million)	Incidence (year-1 10-5)	Annual change (2011-13) (%)	Elimination year under current trends	Decline to reach elimination by 2025
Oman	3.6	10.82	-10.2	2036	-20%

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