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Epidemiological situations and control strategies of vector-borne diseases in Nepal during 1998–2016

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Abstract

Purpose – The purpose of this paper is to investigate epidemiology and control strategies of the four priority vector-borne diseases (VBDs) in Nepal, i.e. malaria, Kala-azar (visceral leishmaniasis), lymphatic filariasis (LF) and dengue fever/dengue hemorrhagic fever.

Design/methodology/approach – The study was a retrospective design to collect data during 1998–2016 from VBDs endemic districts of Nepal. All data were reviewed and epidemiological information of the four VBDs were analyzed.

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Findings – The number of malaria cases during 1998–2016 of the 13 affected districts was declined from 8,498 to 991 cases with no record of deaths since 2012. The number of cases and deaths in the 12 kala-azar (visceral leishmaniasis) affected districts in 1998 was 1,409 and 42 cases, respectively, but was dramatically decreased in 2016 to 213 and 2 cases, respectively. LF cases of the 61 affected districts in 2011, 2014 and 2016 were 28,855, 30,000 and 33,517 cases, respectively. In total, 25 districts achieved elimination target and the remaining are expected to complete the needful cycles by 2018. Dengue incidence of the 31 affected districts during 2006–2015 was under controlled with reported cases of 642, 356 and 136 cases in 2013, 2014 and 2015, respectively, and only one death in 2015. Implementation of control strategies particularly disease management and community peoples' awareness significantly reduced the cases and deaths of the target VBDs.

Practical implications – The results of this study clearly suggest that the current control strategies have been worked effectively. However, in particular of the VBDs, health education in communities in the endemic areas should be adopted for better community participation in the context of the primary health care approach and increase the effectiveness of disease control.

Originality/value – VBDs, i.e., malaria, kala-azar (visceral leishmaniasis), LF and dengue fever/dengue hemorrhagic fever, are major causes of morbidity and mortality in the least developed countries which include Nepal. Globalization of travel and trading, unplanned urbanization, environmental and climate change are having a significant impact on disease transmission. Therefore, the Ministry of Health of Nepal had brought some changes in strategies based on activities for disease control, vector control, preventive and preparedness for outbreak response. Consequently, the cases and deaths due to malaria, kala-azar (visceral leishmaniasis), lymphatic filaiasis and dengue fever/dengue hemorrhagic fever have been brought down markedly.

Keywords Malaria, Dengue hemorrhagic fever, Kala-azar (visceral leishmaniasis), Lymphatic filariasis, Dengue fever, Nepal

Paper type Research paper

Introduction

Malaria, kala-azar (visceral leishmaniasis), lymphatic filariasis (LF) and dengue fever/dengue hemorrhagic fever constitute the major vector-borne diseases (VBDs) that affect more than 1bn cases and over 1m deaths annually[1]. All of these VBDs are prevalent in South-East Asian countries. Specifically, Nepal's geographic position and climatic conditions have been favorable to the transmission of VBDs[2].

There was a massive malaria epidemic in the Far-Western region of Nepal with smaller epidemics in the Central Region from 1985 to 1988. The case number was above 15,000 annually and increased up to 42,321 in 1985. The proportion of *Plasmodium falciparum* was also very high (18–19 percent in 1984 and 1985). However, the cases were brought down again to 22,000 by the end of that decade[3]. Malaria is caused by *Plasmodium* parasites transmitted through the bites of female *Anopheles* mosquitoes with *P. falciparum* and *P. vivax* being the most common cause of malaria[4]. An acute febrile illness like malaria is difficult to diagnose whilst the *P. falciparum* infection can develop into severe malaria and death[5]. The best available treatment, particularly for *P. falciparum* malaria, is an artemisinin-based combination therapy, but the development of drug resistance remains a great concern[6].

Kala-azar (visceral leishmaniasis) is another VBD prevalent in Nepal with approximately 6.5m of the population estimated to be at risk. A total of 28,424 cases and 582 deaths were reported during 1980–2006 and the case fatality rate varied from 0.23 to 3.16[7]. Leishmaniasis is caused by *Leishmania donovani* complex and transmitted by female sandflies (*Phlebotomus* species) after sucking blood from natural reservoirs, i.e. humans, dogs and other animals[4]. The symptoms of the disease are irregular fever, weight loss, spleen and liver enlargement, anemia and are fatal if left untreated[8]. Although highly effective antileishmanial medicines are available, relapse of the disease can occur both in immunocompetent and immunocompromised patients[9]. Furthermore, patients may have indurated nodules or depigmented macules after recovery of the disease called post kala-azar dermal leishmaniasis (PKDL)[10].

LF is another public health problem in Nepal. A survey during 2001–2005 and 2012 revealed a 13 percent average prevalence of LF infection in the country, ranging from < 1 to 39 percent[11]. The disease is caused by thread-like filarial worms, i.e., *Wuchereriabancrofti*, *Brugiamalayi* and *Brugiatimori*[12]. The parasite is transmitted by different types of

mosquitoes and the accumulation of millions of microfilariae (tiny larvae) that circulates in the blood and can then obstruct the lymphatic system and disrupt the immune system[4]. Impairment of the lymphatic system leads to the abnormal enlargement of body parts, causing pain and severe disability[12]. A single dose of albendazole given together with either diethylcarbamazine or ivermectin is the recommended treatment to clear the parasites from the bloodstream while hydrocele (fluid accumulation) can be cured with surgery[4].

Dengue fever/dengue hemorrhagic fever is caused by infection from one of the four closely related dengue viruses (DENV-1, -2, -3 and -4). The first case in Nepal was reported in 2004[13, 14]. The virus is transmitted to humans by the female *Aedes aegypti* mosquito, the primary vector. General symptoms of dengue fever/dengue hemorrhagic fever include severe headache, pain behind the eyes, muscle and joint pains, nausea, vomiting, swollen glands or rash. Patients may present with complications from plasma leaking, fluid accumulation, respiratory distress, severe bleeding or organ impairment[15]. At present, there is no effective antiviral medication for dengue infection treatment and no available commercial vaccine against dengue. In cases of severe dengue, it is critical to maintaining the patient's body fluid volume[4].

All four VBDs significantly impact national development by reducing economic productivity, preventing individuals from being able to work or take care of themselves or their families, and limiting access to education[16]. However, VBDs are preventable diseases if adequate practices are followed. To improve VBD control, the Nepali Government has revised and implemented some strategies in the last decade, i.e., the establishment of the treatment protocol, incorporation of rapid diagnostic kits and active case detection networks. Proper control/elimination of these VBDs requires temporal analysis of the epidemiological situation along with their related problems and control strategies. This study aims to describe the epidemiological situation and control strategies of malaria and priority VBDs in Nepal, i.e., kala-azar, LF, and dengue fever/dengue hemorrhagic fever by analysis of morbidity, mortality and application of strategies related to diseases control and elimination in Nepal. The outcome of this study would be helpful in proper planning and the implementation of an active control/elimination program of these VBDs in Nepal.

Materials and methods

This study was a retrospective design to collect secondary data on malaria and the other three priority VBDs, i.e., kala-azar (visceral leishmaniasis), LF and dengue/dengue hemorrhagic fever, from the respective District Public Health Offices (DPHOs) and Epidemiology and Disease Control Division (EDCD)/DoHS, Teku, Kathmandu. Nepal's diverse geography and climate promote the spread of VBDs.

Malaria

Data were collected from 1998 to 2016, from all *P. falciparum* affected districts (13) with high endemicity, i.e., Jhapa, Illam, Morang, Dhanusha, Mahottari, Sindhuli, Kavre, Banke, Bardia, Nawalparasi, Kailali, Kanchanpur and Dadeldhura.

Kala-azar (visceral leishmaniasis)

Data were collected from 1998 to 2016, from all kala-azar affected districts with high endemicity (12), i.e., Jhapa, Morang, Sunsari, Saptari, Siraha, Udayapur, Dhanusha, Mahottari, Sarlahi, Rautahat, Bara and Parsa.

Lymphatic filariasis

Data were collected between 2003 and 2016, from the country's LF endemic districts (61), i.e., Parsa, Makwanpur, Chitwan, Nawalparasi, Rupendehi, Rauthat, Bara, Kapilbastu, Sarlahi, Dhading, Nuwakot, Dhanusha, Mahottari, Ramechhap, Sindhuli, Sindhupalchock,

Kavreplanchok, Palpa, Tanahun, Syangja, Gorkha, Kathmandu, Lalitpur, Bhaktapur, Kaski, Parbat, Myagdi, Banglung, Arghakhanchi, Pyuthan, Lamjung, Okhaldhunga, Bhojpur, Udayapur, Siraha, Saptari, Rukum, Rolpa, Salyan, Dang Deokhuri, Banke, Bardiya, Surkhet, Jajarkot, Kailali, Kanchanpur, Baitadi, Dadeldhura, Dailekh, Achham, Bajang, Doti, Bajura, Panchthar, Ilam, Jhapa, Terahathum, Dhanakuta, Parbat, Sunsari and Morang.

Dengue fever/dengue hemorrhagic fever

Data were collected from all the districts that had reported dengue cases from 2006 to 2015 (31), i.e., Bara, Bhaktapur, Bhojpur, Chitwan, Dadeldhura, Dang Deokhuri, Doti, Gorkha, Gulmi, Ilam, Jhapa, Kailai, Kanchanpur, Kapilbastu, Kaski, Kathmandu, Kavre, Mahottari, Makwanpur, Nawalparasi, Palpa, Parsa, Pyuthan, Rauthat, Rupendehi, Saptari, Sarlahi, Siraha, Syangja, Tanahun and Udayapur.

Data analysis

All data were reviewed and analyzed to obtain an overview of the epidemiological situation of the four priority VBDs in Nepal. The following parameters were included: morbidity rate, mortality rate, prevalence, distribution and disease control strategies. Descriptive statistics were applied for both quantitative and qualitative data and summarized as number or percentage using graphs, tables or figures (Microsoft excel and SPSS 15.0 programs).

Results

Epidemiological situation

Malaria. Among the five types of human malaria, only *Plasmodium vivax* and *P. Falciparum* are found in Nepal. The number of total malaria cases *(P. falciparum* and *P. vivax)* during 1998–2016 varied between 991 and 12,750 cases. Figure 1 shows malaria incidence in Nepal during the period which defined the proportion of *P. falciparum* and the remaining proportion belonging to *P. vivax*. In 1998, the proportion of patients with *P. falciparum* was recorded as the second-lowest year; 7,978 out of the total 8,498 cases (94 percent) were *P. vivax* and only 520 (6 percent) were *P. falciparum*. In a later year, the proportion of *P. falciparum* tended to increase up to 27 percent in 2010. The incidence of malaria including *P. falciparum* cases was generally in decline from 2002. During 2004–2007, the

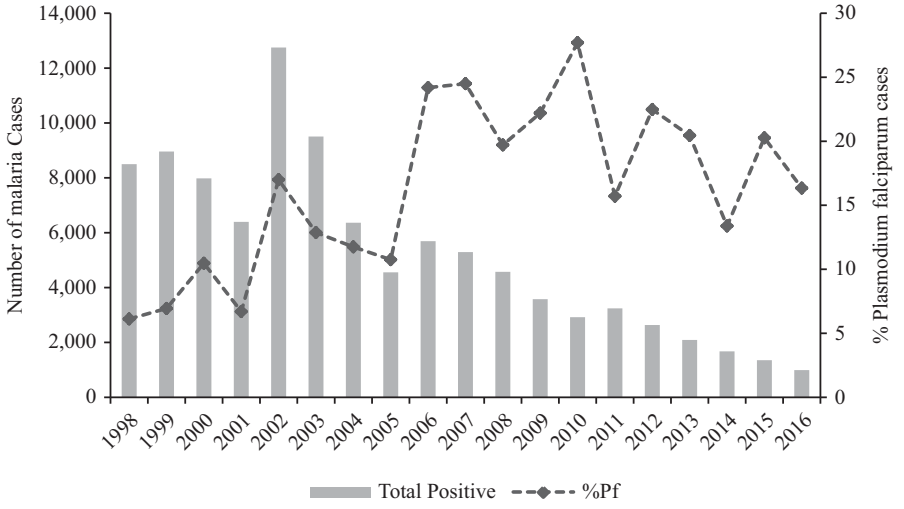

Figure 1.
Malaria incidence in Nepal during 1998–2016 with the proportion of *Plasmodium falciparum*, Pf (%) and the remaining proportion represents the proportion of Pv (%)

number was decreased to be maintained at approximately 5,000 cases. From 2008 onwards up to 2016, malaria cases gradually declined to about 1,000 cases. No death was reported from 2012 up to 2016. The number of malaria cases nationwide peaked in June–July of each year. However, a trend for malaria to peak in August was observed in the highland area. Gender distribution of the cases in 2015 indicated that males were significantly more susceptible than females (71 and 29 percent). Malaria cases reported in patients aged less than five years were 4 percent and those above five years was 96 percent.

Kala-azar (visceral leishmaniasis). In 1998, a total of 1,409 cases including 42 deaths were reported from 12 kala-azar (visceral leishmaniasis) endemic districts. The highest number of cases was reported in 2003 (2,229 cases), while the highest number of deaths was reported in 2000 (50 cases). The trend of kala-azar (visceral leishmaniasis) cases and death has been in significant decline since 2006 (1,531 cases and 14 deaths). In 2015 and 2016, the number of cases significantly dropped to 220, and 213 cases with only zero to two reported deaths (Figure 2). In addition, kala-azar (visceral leishmaniasis) incidence per 10,000 of the population decreased to be less than 1 since 2009. Monthly distribution of the disease began in February and peaked during April, May and June, and then gradually declined until the end of the year. Among the 213 kala-azar (visceral leishmaniasis) cases reported in 2016, 2 percent were less than five years of age, whereas 98 percent were over five years. Sex-wise distribution revealed the predominance of males (65 and 35 percent males and females).

Lymphatic filariasis. Among the three types of lymphatic parasites, only *Wuchereriabancrofti*is was recorded in Nepal. LF is endemic in 61 of the 75 districts as confirmed by a blood test (Immunochromatography Card Test (ICT)). In 2001, based on the mapping of filarial infection using ICT, the prevalence of LF in 11, 15 and 7 districts was 20, 6–19 and 1–5 percent, respectively. Baseline microfilaremia surveys in nocturnally collected blood were carried out in the 29 districts prior to the initiation of the mass drug administration (MDA) program in 2003 and showed that microfilaria prevalence varied from 1 to 11 percent. Among the 29 districts, the prevalence of microfilaria was found to be

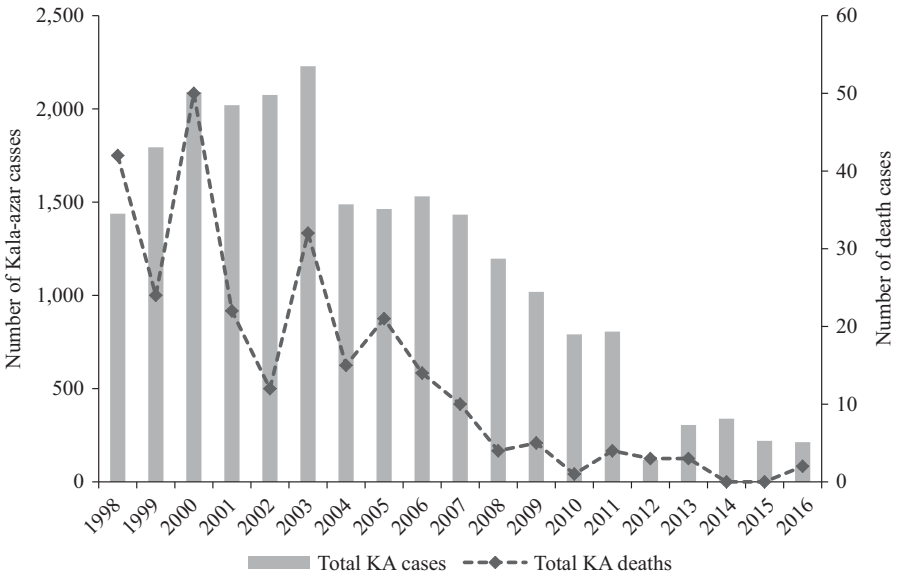

Figure 2.
Kala-azar cases and death in Nepal during 1998–2016 (KA: Kala-azar)

highest in Dhading (11.67 percent). Reports of cases with LF symptoms (hydrocele, lymphoedema/elephantiasis, hand, breast, swelling, etc.) were available in 2003, 2004, 2011, 2014 and 2016 (809, 1,681, 28,855, 30,000 and 33,517 cases, respectively) (Figure 3).

Dengue fever/dengue hemorrhagic fever. Dengue fever/dengue hemorrhagic fever was reported in Nepal for the first time in 2004 from Chitwan district, the central region of the country, and then regularly reported from 2006 onwards. The number of cases reported during 2006–2009 was relatively low (10–32 cases). The disease outbreak occurred in 2010 with 917 reported cases of dengue fever and five deaths. The outbreak occurred again in 2013 with 785 reported cases with no death (371 of 785 cases were reported from Chitwan). In the following years, the recorded cases declined and only one death was recorded in 2015 (Figure 4). Dengue outbreak was officially documented in 2006 when the highest number of cases (75 percent) was reported in October, followed by September and November. Among the total cases identified, 94 percent were adults with males more predominant than females (80 and 20 percent, respectively). Similar to the record in 2015, the number of dengue fever cases was highest in October (39 cases) and September (35 cases), and then declined in November (11 cases). The disease was most common amongst the elderly, children, adolescents and adults. Both sexes were susceptible to Dengue fever/dengue hemorrhagic fever. However, it was estimated that 90 percent of the dengue hemorrhagic fever cases occur in children under the age of 15 years.

VBDs control strategies and effectiveness

Nepal attempts to control morbidity and mortality of malaria, kala-azar, LF and dengue fever/dengue hemorrhagic fever by implementing suitable control strategies and a regular monitoring system (Table I).

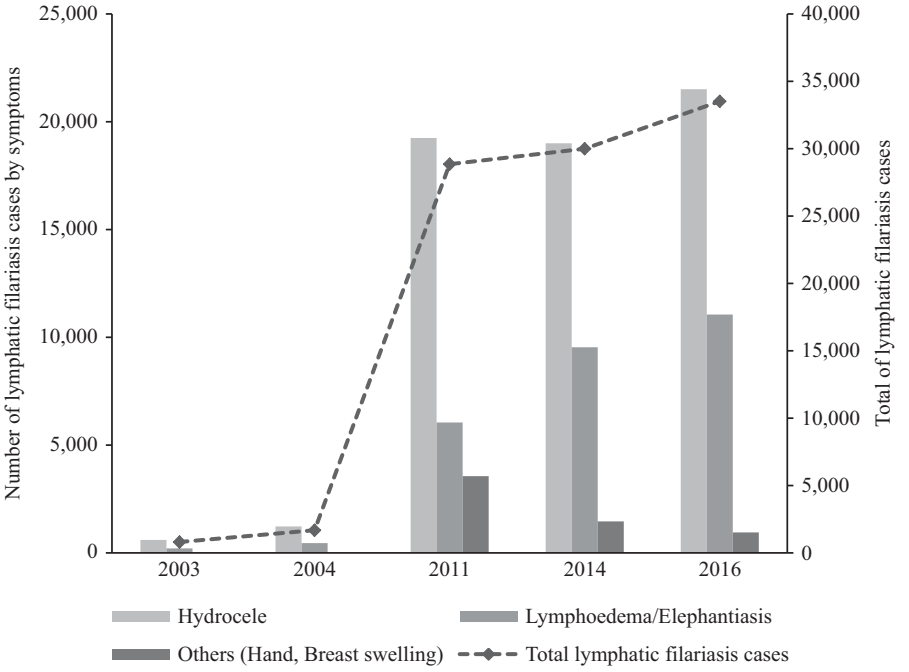

Figure 3.
Lymphatic filariasis cases in Nepal during 2003–2016

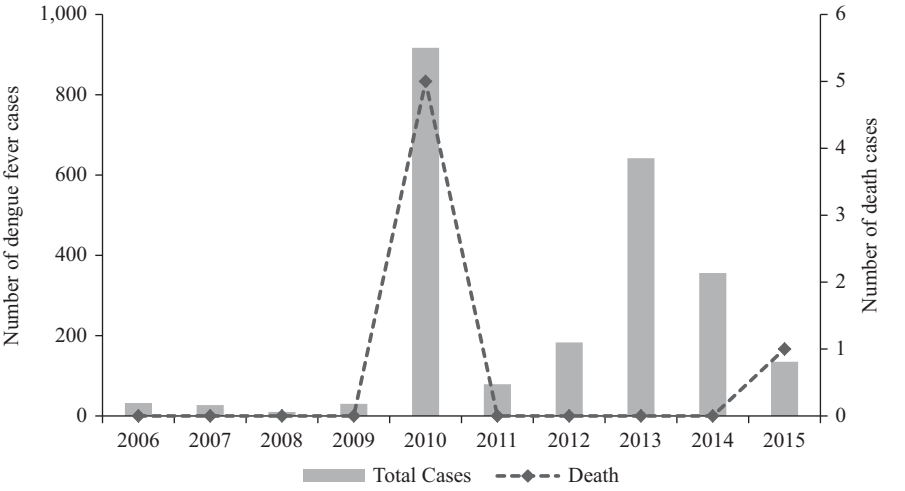

Figure 4.
Dengue fever/dengue hemorrhagic fever cases and deaths in Nepal during 2006–2016

Malaria

The target of malaria control in Nepal is disease elimination by 2026 and zero death case by 2015[17], and reduction of locally transmitted malaria incidence by 90 percent of current levels (2010) by 2016[18].

Control strategies and effectiveness. Nepal's malaria control strategy has been regularly revised and the latest strategies used during 2013–2016 are summarized (only strategies I, II and IV have been applied since 1998) as follows:

Strategy I: early diagnosis and prompt treatment of malaria cases:

(1) Effectiveness:

- malaria suspected cases accessed to microscopic and RDT diagnosis were 56 percent in 2010[18];
- malaria confirmed cases receiving appropriate treatment were 100 percent in 2010[18];
- total malaria cases in 2016 were reduced to about 90 percent in 1998 and 75 percent in 2010; and
- there were no reported deaths after 2012.

Strategy II: indoor residual spraying (IRS) and distribution of long-lasting insecticide-treated bed nets (LLINTs):

(1) Effectiveness:

- 90 percent annual IRS household was achieved in 2009[18]; and
- 5m LLINs were distributed in endemic areas[19].

Strategy III: clinical suspected malaria confirmation:

(1) Effectiveness:

- Clinically suspected malaria cases during 2013–2016 were decreased to 10,600.

Strategy IV: various levels of health personnel training:

(1) Effectiveness:

VBDs and control strategy duration	Target	Control strategies and intervention	Effectiveness/outcome
Malaria (strategic duration: 1998–2016)	Malaria elimination from Nepal by 2026 Zero death due to malaria by 2015[20] Reduction of locally transmitted malaria incidence by 90% of current levels (2010) by 2016[21]	Early diagnosis and prompt treatment (EDPT) Use RDT kits for diagnosis Prescribe artemether combination with lumefantrine for falciparum malaria treatment and chloroquine combination with primaquine for vivax malaria	Malaria suspected cases accessed by a microscope or RDT diagnosis was 56% in 2010[21] Malaria confirmed cases received appropriated treatment was 100% in 2010[21] Total malaria cases in 2016 reduced about 90% of case numbers in 1998 and 75% of cases number in 2010 No death case since 2012
		Vector control Perform IRS to control vector Distribute LLINTs to protect mosquito's bite	Yearly IRS Household was90% in 2009[21] The distribution of around 5 million LLINs in endemic areas[22]
		Improvement of health personnel skill Set up yearly training for all stakeholders involved in malaria control to up-date malaria control techniques	Staff received adequate necessary training Reliability and precision of data collection, as well as case management, are improved
Kala-azar (strategic duration: 1998–2016)	Reduction of the annual Kala-azar incidence and the fatality rate to be less than 1 case per 10,000 populations at the district level to less than 1 percent by the end of 2015	Early diagnosis and complete treatment Provide RDT kits for diagnosis Prescribe Miltefosine combination with liposomal amphotericin B for treatment	Kala-azar incidence and the fatality rate was less than 1 case per 10,000 populations at the district level to less than 1 percent since 2012
		Vector control Perform IRS to control vector and distribute LLINTs to protect sandflies' bite	Kala-azar vector, sandflies, is controlled. People are safe from sandflies' bite
		Social mobilization and partnership building Set up activities to promote collaboration at all local and national levels for disease control	People can exchange information, respond to questions and doubts, convince and motivate others to adopt certain behavioral practices[22]
Lymphatic filariasis (strategic duration: 2003–2016)	MDA covered in all endemic districts by 2014 Elimination of lymphatic filariasis from public health problem by 2020 [23]	Mass drug administration Launch MDA by giving DEC and albendazole to the population living in endemic districts for prophylaxis Prescribe of DEC and albendazole for treatment	Achievement of 100% geographical MDA coverage in 2013 and all will complete the 6 rounds of MDA cycle by 2018
		Morbidity management and disability prevention Provide home-based self-care by people living with	All health workers were trained on patient self-care in morbidity mapped districts, Saptari and Okhaldhunga[22]

(*continued*)

Table I.
The main VBDs control strategies in Nepal and effectiveness

VBDs and control strategy duration	Target	Control strategies and intervention	Effectiveness/outcome
		lymphedema and elephantiasis	The lymphatic filariasis cases received proper management.
		Provide hospital-based management and surgical corrections of hydroceles	Total of 2,172 hydrocele surgeries have been performed during 2016–2017[22]
		Post-MDA surveillance	Total of 25 districts completion of 6 rounds of MDA passed
		Perform transmission assessment survey (TAS)	TAS
Dengue fever/ dengue hemorrhagic fever (strategic duration: 2007–2016)	Reduction of the burden of Dengue fever/dengue hemorrhagic fever[24]	Early case detection	The cases reported in 2015 decreased by 38% compared to 2014 and by over 55% compared to 2013
		Perform active surveillance for searching for new cases	Only one death in 2015
			No record of dengue fever outbreak since 2014
		Integrated vector control	*Aedes aegipti* was identified as mosquito vector which has been searched and destroyed from the endemic districts
		Apply several approaches to reduce vector such as identification and surveillance of transmitted vector and elimination of breeding source	

Notes: RDT, rapid diagnostic test; IRS, indoor residual spraying; LLINTs, long-lasting insecticide-treated bed nets; MDA, mass drug administration; DEC, diethylcarbamazine

Table I.

- All public health personnel (e.g. physicians, nurses, epidemiologists and vector control inspectors), teachers, journalists and community leaders received the adequate necessary training.

Strategy V: entomological researches:

(1) Effectiveness:

- Susceptibility of malaria vectors has been carried out every year. Consequently, the knowledge of the malaria vector has been updated and ready to apply for vector control.

Strategy VI: monitoring and evaluation of the epidemiological situation:

(1) Effectiveness:

- Reliability and precision of data collection, as well as case management, is improved; the performance was evaluated every three months.

Strategy VII: early warning reporting system (EWARS):

(1) Effectiveness:

- Districts where EWARS was adopted were increased from 8 (in 1998) to 60 (during 2013–2016) districts. The information is useful for disease control.

Kala-azar (visceral leishmaniosis)

The target for the kala-azar elimination program is to reduce the annual incidence rate of the disease to less than 1 per 10,000 populations in all endemic districts in Nepal by the year 2015.

Control strategies and effectiveness. The strategies used for the control of kala-azar (visceral leishmaniosis) during 1998–2016 were as follows.

Strategy I: improvement of program management:

(1) Effectiveness:

- Strengthening the capability of diagnosis and treatment centers were expanded to peripheral health centers with the availability of rk39 kits.

Strategy II: early diagnosis and complete treatment:

(1) Effectiveness:

- Incidence and fatality rates were less than 1 case per 10,000 at the district level to less than 1 percent since 2012.

Strategy III: integrated vector management (IVM):

(1) Effectiveness:

- IRS and LLINT were helpful in population control of sandflies, bite protection from sandflies, as well as interruption of transmission.

Strategy IV: effective disease and vector surveillance:

(1) Effectiveness:

- Kala-azar (visceral leishmaniasis) outbreak/epidemic was not reported since 2012.

Strategy V: social mobilization and partnership building:

(1) Effectiveness:

- "KA week" for case detection and treatment campaigns have been organized every year to improve disease awareness. Consequently, people can exchange information, respond to questions and doubts, convince and motivate others to adopt certain behavioral practices[19].

Strategy VI: clinical, implementation and operational research:

(1) Effectiveness:

- research on sodium antimony gluconate (SAG) was performed to evaluate the status of drug efficacy;
- entomological studies are being done once a year regularly; and
- the knowledge of disease management has been updated.

Lymphatic filariasis

The target of LF elimination is MDA covering in all 61 endemic districts by 2014 and disease elimination by 2020[20].

Control strategies and effectiveness. The essential LF control strategies during 2003–2016 were:

(1) MDA: diethylcarbamazine (DEC) and albendazole administration in populations living in endemic districts once every year for a period estimated to be at least five years for prophylaxis:

- Effectiveness:
  - LF cases have reduced. The implementation of MDA to all LF endemic districts (61) was achieved in 2013 (100 percent geographical coverage). By the

year 2016, MDA had been completed in 25 districts (six rounds and the program was expected to be completed in all districts by 2018).

(2) Morbidity management and disability prevention: home-based self-care for people living with lymphedema and elephantiasis and hospital-based management and surgical corrections of hydroceles:

- Effectiveness:
  - All health workers were trained on patient self-care in morbidity mapped districts[19].
  - The LF cases received proper management; a total of 2,172 hydrocele surgeries were performed during 2016–2017[19].

(3) Post-MDA surveillance: transmission assessment survey (TAS):

- Effectiveness:
  - 25 districts completed six rounds of MDA (fulfilled TAS).

Dengue fever/dengue hemorrhagic fever

The target of dengue fever/dengue hemorrhagic fever is the reduction of disease burden focusing on the reduction of disease mortality by at least 50 percent in 2020 and reduction of disease morbidity by at least 25 percent in 2020[21].

Control strategies and effectiveness. The effective strategies to control the disease involved early diagnosis and prompt management of the cases and vector control. The strategies implemented to control dengue fever/dengue hemorrhagic fever during 2007–2016 were as follows.

Strategy I: early case detection, diagnosis, management and reporting of dengue fever/dengue hemorrhagic fever cases

(1) Effectiveness:

- The dengue fever/dengue hemorrhagic fever affected districts were identified and placed under active surveillance which resulted in a significant decrease in reported cases. The cases reported in 2015 were decreased by 38 percent compared to 2014 and by over 55 percent compared to 2013.

Strategy II: regular monitoring of dengue fever/dengue hemorrhagic fever cases and surveillance through early warning reporting system:

(1) Effectiveness:

- Regular monitoring of DF/DHF cases and surveillance were implemented through EWARS. This assisted in preventing epidemic occurrence.

Strategy III: mosquito vector surveillance in different municipalities:

(1) Effectiveness:

- Vector surveillance has regularly been carried out in affected municipalities.

Strategy IV: integrated vector control approach:

(1) Effectiveness:

- *Aedes aegipti* was identified as mosquito vector. The vector has been searched and destroyed from the endemic districts.

Strategy V: information education and communication (IEC) activities and awareness generation for community involvement:

(1) Effectiveness:

- Regular IEC activities were run to generate people's awareness of community involvement to destroy mosquito breeding sources and self-protection measures were publicized.

Discussion

Malaria has been a major VBD threat in Nepal for several decades. Substantial progress in malaria control was made during 1998–2016 contributing to a significant decline in clinical and confirmed malaria cases and the number of affected endemic districts. Since 2012, mortality due to malaria has been maintained at zero level. The decline of malaria cases from 2003 to 2016 was due to implementation of a multidivisional program comprising vector control, provision of effective antimalarial drugs for the treatment of malaria, reliable diagnostic facilities, health personnel training and people's awareness of the disease. Although the reported *P. falciparum* cases rose to about 20 percent from 2006 onwards, this was due to an increase in imported cases rather than indigenous cases or malaria outbreaks. The cases identified in new areas, particularly hilly terrains, are of concern as it will hamper the achievement of malaria elimination endeavor in Nepal. Furthermore, climate change becomes a recent factor for malaria infection in higher altitudes of Nepal where malaria vectors are already established in spite of the general belief is that malaria transmission is not possible in the areas[22].

For kala-azar (visceral leishmaniasis), up until 2016, the number of cases significantly dropped during the last several years and the country achieved the target to reduce annual disease incidence rate to less than 1 per 10,000 populations at the national and district levels. Although disease control strategies had been implemented since 1998, there were minor revisions in detail of Strategy II. This included early diagnosis and complete treatment by replacement of SAG prescription to miltefosine and amphotericin B. In addition, the increase in the number of treatment and diagnostic centers resulted in a sharp decline of kala-azar incidence from the year 2003 to 2004. The revised National Strategic Guideline on Kala-azar Elimination in Nepal in 2010 recommended using rk39 as an RDT kit and miltefosine as the first-line treatment except in some situations where the medicine cannot be used such as during pregnancy, breastfeeding mothers or for children less than two years of age. In these patient groups, Liposomal Amphotericin B (L-AmB) was suggested for treatment[23]. The recent revision of National Strategic Guideline in 2014 recommended introducing L-AmB and combination regimens for KA and PKDL treatment to improve the efficacy of case management and reduced disease transmission. The number of kala-azar cases therefore slightly declined up to 2016. Nevertheless, the efforts to bring down the cases and deaths need to be maintained since several implementation problems/constraints still exist. The disease transmission dynamics had not been investigated resulting in the lack of information on extensive entomological surveys/studies, a reservoir of the infection and host/parasite interaction. Treatment efficacy evaluation or pharmacovigilance of antileishmanial drugs should be performed routinely to collect information on treatment failure cases, as well as the type of treatment received from government and non-government health institutions[24].

LF is another VBD affecting Nepal in 61 of 75 districts. Nevertheless, compared to malaria and kala-azar, few reports have been documented in Nepal[25]. In 1997, 12.75 percent microfilaria infection and 11.95 percent incidence rate of *W. Bancrofti* was reported with a higher incidence among females (16.59 percent) compared to males (8.49 percent) [26]. Another survey conducted in 1999 showed 5.8 percent prevalence of

overall microfilaria infection with the highest proportion (11.8 percent) of cases amongst the 40–49 year age range[27]. WHO initiated the LF Global Elimination Program in 2000 with the aim to eliminate the disease globally by the end of 2020. The essential strategy is to treat the entire at-risk population once every year for a period estimated to be at least five years. The decrease in LF incidence during 2003–2016 was a result of the implementation of active surveillance for new endemic districts identification, house to house visiting and an improved recoding system for MDA coverage. Nepal launched this MDA program in 2003 and covered all LF endemic districts (61 districts) in 2013. By the year 2016, altogether 25 districts completed six MDA cycles and achieved elimination targets as suggested by the report of post-MDA microfilaremia survey and TAS[28, 29]. In addition to MDA and TAS, the important activity including home-based self-care for people living with lymphedema and elephantiasis and hospital-based management and surgical corrections of hydroceles was carried out to promote control strategy effectiveness.

Dengue fever/dengue hemorrhagic fever is an emerging disease in Nepal. The disease has been expanding to several districts, particularly in the Tarai areas more than the hilly regions[25]. The first case of dengue fever was reported in Chitwan district, in the central region of the country with case numbers during 2006–2009 remaining low until the disease outbreak in 2010. The outbreak of dengue fever/dengue hemorrhagic fever occurred at an interval of about three to four years and effective control strategy became a great concern. With the implementation of the Dengue Fever Control Program, the disease affected districts were identified under the active surveillance system[30]. Furthermore, the provision of reliable diagnostic kits facilitated the preventive intervention by vector control with spraying or breeding source reduction. Consequently, the case number of dengue fever greatly declined in 2011. Moreover, the case number of outbreaks reported in 2013 was not as high as that in 2010 and further declined in 2014–2015. The increasing trend for the migration of people from rural to urban areas where mosquito vectors are more commonly found suggests that a growing proportion of the population would be under threat of infection in future[30]. The presence of a single case may have a significant impact on disease control as it could lead to a disease epidemic. Therefore, one should always be alert to protective measures from mosquito bites as the program and cheapest form of prevention. In addition to the adequate budget allocation for the program, other strategies should be implemented, i.e., strategy development and planning for disease management, laboratory diagnosis, vector surveillance, IVM, case reporting, training/orientation of all levels of medical staff and coordination with each municipality for vector "search and destroy" type activities.

VBDs in Nepal are a serious public health concern with more than 80 percent (65/75) of Nepal's districts threatened by at least one VBD and ten districts lying in very high hills and mountainous areas that are free from VBDs. Nepal is a landlocked country with diverse geography of Terai (foothills) and hilly through to mountainous (Himalayas) regions sharing borders in the north with the Tibetan region of China and other borders with India[31]. Furthermore, Nepal's climate of extreme and widely fluctuating temperatures, rainy and winter seasons, as well as periods of humidity, are all known factors that promote VBDs[22,32].

Among 65 malaria-endemic districts, *P. vivax* malaria was reported in all 65 districts of which there were 13 high *P. falciparum* malaria incriminated districts located in the eastern, mid-western and far-western regions. Kala-azar was found in 12 districts of the eastern and central regions where the prevalent ecological system such as temperature and rainfall was suitable for vector breeding [2]. In addition, poor living quality, insufficient health facilities and case importation from free movement along borders with India also allowed disease transmission. LF was found in all developing regions. The efficient vector, *Culex quinque fasciatus* mosquito which promotes disease transmission, has been found in all endemic areas of the country[19]. The mosquitoes were established in endemic districts located in

areas of 70–2,300 m above sea level with unhygienic, blocked drainage, slum areas and dirty places. Its breeding habitat is very simple since it can occur in seepage locations to waterlogged containers[2, 22]. The people living in urban areas, suburban areas and also villagers have equal opportunities of being infected. Dengue fever/dengue hemorrhagic fever was reported in 31 districts distributed throughout the southern lowland Terai from the east to the west and also in some less elevated river valleys in the hill and mountain regions. The highest dengue transmission was observed in areas lower than 300 m above sea level[33]. The absence of dengue fever/dengue hemorrhagic fever case in a few more districts in the mid-western, eastern, central and western regions was the hilly or high mountainous areas[2, 33]. With the implementation of active surveillance, dengue fever/dengue hemorrhagic fever cases were found in new districts every year, although Chitwan, Parsa, Bara, Nawalparasi and Rupendehi districts are established as permanent endemic foci. This study found that there were two districts, i.e., Jhapa in the eastern region and Mahottari in the central region which were affected by malaria, kala-azar, LF and dengue fever/dengue haemorrhagic fever.

Case importation from neighboring countries significantly impacts VBD control in Nepal and therefore both international and national factors need to be considered with the effective strengthening of VBD control through international collaboration. The countries in WHO-SEARO also attempt to control the VBD situation in their countries and apply the IVM by using IRS and LLIN in high-risk areas[34]. The Indian Government has introduced prevention measures for all VBDs to ensure elimination by 2022[35–38]. Bangladesh too has introduced strategies to eliminate and reduce the spread of VBDs through vector control, surveillance, health system research and, advocacy, communication and social mobilization [39,40]. In spite of these regional efforts, financial status and geography continue to deter effective strategic implementation[41]. VBD control is further complicated by populations crossing between Bangladesh, Bhutan, India and Nepal. By means of resolution, a cross-border environmental health project has been developed with the aim to achieve inter-country agreement regarding surveillance and diagnosis standards for priority VBDs, and inter-country communications networks for behavior change communication strategies, information dissemination, and data and information sharing[42].

Conclusion

The implementation of strategies for the four VBDs in Nepal has resulted in the effective control of these diseases. The main strategies included disease management with early diagnosis and treatment, vector control, and community awareness. Nevertheless, free movement across borders, efficient vectors responsible for transmission, geographical factors as well as climate change can facilitate the re-emergence of VBDs. Therefore, regular evaluation of the control strategies and the strengthening of international collaboration are necessary to maintain VBD control in Nepal.

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