Review Article

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Diurnally subperiodic filariasis among the Nicobarese of Nicobar district - epidemiology, vector dynamics & prospects of elimination

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In India diurnally subperiodic filariasis (DspWB) is prevalent only in the Nicobar district of Andaman and Nicobar Islands. Studies undertaken at different points of time indicate that this form of filariasis is restricted to a small region in Nancowry group of islands where it is transmitted by mosquito *Downsiomyia nivea*, a day biting mosquito. Studies on prevalence, distribution, and assessment of endemicity status, vector incrimination, bioecology, host seeking behaviour, population dynamics of the vector, transmission dynamics and clinical epidemiology indicate the prevalence and persistence of this infection in the Nancowry group of islands with perennial transmission. There was no control programme in these islands, until the National programme to eliminate filariasis was launched in 2004. Eight rounds of annual mass drug administration (MDA) with diethyl carbamazine (DEC) + albendazole have been completed. Despite this, microfilaria prevalence remains at above one per cent, the level identified for initiating transmission assessment survey to decide on continuation of MDA further. This necessitates adjunct measures to the ongoing MDA programme in these islands. The vector control options could be an adjunct measure, but the vector is a forest dweller with a unique bio-ecology, therefore, not a technically feasible option. Use of DEC fortified salt for six months to one year could hasten the process of elimination. Although administration of DEC-fortified salt is simple, rapid, safe, and cost-effective, challenges are to be tackled for evolving operationally realistic strategy. Such a strategy requires commitment of all sections of the society, a distribution mechanism that ensures the use of DEC-fortified salt in the Nancowry islands. Here we discuss the plan of action to serve the indigenous communities and operationalizing DEC fortified salt strategy through an inter-sectoral approach involving multiple stakeholders.

Key words Andaman Nicobar Islands, India - elimination - lymphatic filariasis - subperiodic - Nicobarese - *Wuchereria bancrofti*

Introduction

Lymphatic filariasis (LF) is prevalent in tropical and sub-tropical countries, and an estimated 120 million people are affected in 73 endemic countries[1], with an estimated 1.393 billion people residing in areas where indigenous transmission is evident. Global programme to eliminate filariasis recommended by the WHO was launched in 2000[1]. The disease is caused by three closely related nematode parasites (*Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori*).

Wuchereria bancrofti is widely distributed accounting for 90 per cent of all human LF infections, and the remaining is due to *B. malayi* and *B. timori*, which are limited to only Asian countries. Co-infection of *W. bancrofti* and *Brugia* parasites has been observed in certain localities of Indonesia[2]. In India, LF is endemic in 20 States with about 610 million people residing in endemic areas[1,3]. Thus LF continues to be an important public health problem in India contributing about 44.3 per cent of the global burden[1]. Bancroftian filariasis is transmitted by *Culex quinquefasciatus* while Mansonoides mosquitoes that breed in close association with hydrophytes such as *Pistia*, *Eichhornia* and *Salvinia* are the vectors of Brugian filariasis[2]. Physiological variants in the genera *Wuchereria* and *Brugia* are of epidemiological significance. Three variants/physiological races in *Wuchereria* and one in *Brugia* have been distinguished based on the circadian pattern of circulating microfilariae (*mf*) in the peripheral blood of humans. The first is the nocturnally periodic *W. bancrofti* (NpWB) variant, distributed in patches widely throughout tropical and sub-tropical zones of the world, in which *mf* appear in peripheral blood circulation only during night, transmitted by *Cx. quinquefasciatus*. The second is the diurnally subperiodic *W. bancrofti* (DspWB), restricted to the south western Pacific island groups and the Indian ocean islands of the Andaman and Nicobar, where *mf* appear in peripheral blood circulation at any time, but in high counts during daytime. The third is a nocturnally subperiodic *W. bancrofti* (NspWB), reported mainly in southern Asia, especially along the sylvan areas contiguous to the Thailand-Myanmar border, northern Vietnam, Sabah (Malaysian Borneo) and the Philippines[4-7]. Microfilariae of the two subperiodic forms are present in peripheral blood 24 h per day with peak densities in the late afternoon and early evening hours (1800-2000 h)[8]. Tewari *et al*[9] showed that the density of *mf* in the peripheral blood of humans was highly variable, with a peak at 1800 h and a trough between 0300 and 0600 h. The fourth one is the nocturnally periodic *B. malayi* (NpBM), where *mf* appears in peripheral blood circulation only during night, present in single largest focus in the central coastal part of Kerala, and small isolated foci in six other States. These variants/physiological races have different mosquitoes as their intermediate hosts, and the *mf* periodicity of each coincides with the circadian rhythm of the biting activity of its primary vector mosquito. This phenomenon is an adaptation to the nocturnal biting behaviour of the primary vectors. *Anopheles* species in rural areas or *Cx. quinquefasciatus* in urban areas[10] are the vectors for the NpWB and certain *Aedes*, *Downsiomyia* and *Ochlerotatus* species are the vectors for the NspWB and DspWB prevalent in southeast Asia and western Pacific. The NpWB and DspWB forms of LF are prevalent in India. While the NpWB transmitted by *Cx. quinquefasciatus* is widely distributed in 20 States and Union Territories of India, the DspWB form transmitted by *Do. nivea* (=*Ochlerotatus niveus*) is restricted to only in the Nancowry group of Andaman and Nicobar islands[11,12]. *Ochlerotatus* (*Finlaya*) *niveus* was reclassified and is currently known as *Downsiomyia nivea*[13]. It has been reported that this species and some members of this group have also been implicated in the transmission of NspWB form of filariasis in Thailand[8]. Prevalence, distribution, clinical epidemiology, vector incrimination, transmission dynamics, bioecology of the vector, control of this form of lymphatic filariasis, post mass drug administration (MDA) scenario, prospects of elimination and action plan for its elimination are discussed here.

Andaman & Nicobar (A&N) Islands - Topography and climate

The A & N Islands (68–14^{0}N and 928–94°E) have three districts, North and Middle, South Andaman and Nicobar, which include about 500 islands, with a population of 3,79,944[14]. The Andaman district covers the northern islands and the Nicobar district covers the southern islands. The Nancowry group of islands of the Nicobar district is a small pocket comprising seven remotely located islands, Bompoka, Chowra, Kamorta, Katchal, Nancowry, Teressa and Trinket. There are 10,488 people[14], mainly constituted by the native Nicobarese tribes who are at the risk of acquiring this form of filarial infection.

Mean minimum temperatures range between 22.97°C (January) and 25.44°C (March) and mean maximum temperature between 28.31°C (January) and 32.36°C (March). The relative humidity (RH) is high and ranges between 72.9 per cent (January) and 87.0 per cent (November). Rainfall is heavy from May to November, and is influenced by both the southwest and northeast monsoons. In the other months, rainfall is generally low, with February being the driest month. The rainfall ranges between 32.7 mm (March) and 351.1 mm (May). The soil is porous coral sand, quickly absorbing the rainwater and leaving hardly any water stagnant. Tree holes have been reported to be the major water holding receptacle supporting breeding of *Do. nivea* in the Nancowry group of islands[9].

Prevalence of DspWB in Nicobar group of Islands

The prevalence of LF in Andaman and Nicobar districts in India was identified as early as in 1942[11]. About 5.8 per cent of the population in Nicobar group was found positive for *W. bancrofti*, while the Andaman group of islands was free from filariasis. Subsequently, sample surveys conducted in 1958[12] showed the prevalence of *W. bancrofti* in Port Blair (Andamans) and Nancowry (Nicobars). In the Nicobar Islands, 7 and 9 per cent *mf* prevalence rates were observed among the population surveyed during day and night, respectively[12].

The first report of DspWB among the Nicobarese originated from the observations in 1974[15]. Only two villages in Kamorta island and one in Nancowry island were covered during the survey which showed *mf* rates of 12.3 and 1.7 per cent, respectively. Age and gender specific analysis of cases showed that the infection was confined to males > 20 yr of age only. Subseqently Russel *et al*[16] undertook a day/night survey of 6250 and 491 individuals in four islands of Nicobar district and Port Blair town (Andamans). The survey showed two distinct forms of *W. bancrofti* infection *viz*. NpWB in Port Blair and a DspWb in Nancowry and Chowra islands. A low (0.3%) *mf* rate in Car Nicobar, medium (4.9 and 3.9%) in Port Blair and Nancowry, respectively and high rates of 15.8 per cent in Teressa and 13.4 per cent in Chowra were recorded. Clinical manifestations were recorded among 90 of the total 6741 individuals with both the genders being affected. Lymphoedema associated with hydrocele was the commonest clinical manifestation[16]. After nearly a decade and a half, Tewari and co-workers[9] undertook studies during the monsoon season which confirmed the existence of DspWB in Nicobar islands. Assessement showed that the *mf* rate was lowest in Trinket (1.2%) and highest in Kamorta (18.7%). The overall disease rate was only 1.9 per cent, the highest being 2.5 per cent from Chowra. Lymphoedema of the lower limbs was the predominat manifestation. No information on the prevalence of hydrocele was available.

Circadian rhythm of *W. bancrofti* microfilaria

Diverse assumptions have been put forth on the mechanism of circadian rhythm. Hawking and Thurston[17] established that intermittent fluctuations in the number of *mf* were due to their accumulation in the lungs during the day and release to the circulating blood at night. Stimulus like body temperature has shown to have effect on the circadian rhythm of *mf* of different filarial species[18]. Subsequently, it was put forth that accumulation in lungs was due to greater oxygen tension in the lungs during the day *vis-a-vis* in the night when the host is under rest[19,20].

In three islands of Nancowry group, *mf* were observed throughout the 24 h period without any distinct peak. The density of *mf* was relatively lower than that of periodic form[15]. Subsequent studies on circadian rhythm in *mf* of *W. bancrofti* established the existence of NpWB at Port Blair (Andamans) and DspWB form in Nicobar group of islands. The existence of both forms in the same host was found in a settler in Nancowry Island[21]. Similar observations with 15 male volunteers from Chowra island[9] also showed that the circulating *mf* were present in the peripheral blood throughout the 24 h. The *mf* counts were found to vary widely during different periods with a peak at about 1800 h and a trough between 0300 and 0600 h in an individual[9].

Mosquito susceptibility and host spectrum in filariasis transmission

Several species of the genera *Anopheles*, *Mansonia*, *Culex* and *Aedes* mosquitoes have been implicated as vectors of human LF. *Culex quinquefasciatus*, *Cx. pipiens molestus*, *Cx. pipiens pipiens*, *An. sinensis*, *An. gambiae*, *An. melas*, *An. meras* and *An. maculatus* are natural vectors of periodic *W. bancrofti*. DspWB is transmitted by *Do. nivea*, *Aedes oceanicus*, *Ae. polynesiensis* and *Ae. pseudoscutellaris*[22].

At least four mosquito species/species groups *Ae.* (*Finlaya*) *niveus* group (=*Do. nivea*), *Ae.* (*Stegomyia*) *scutellaris* group, *Mansonia* (*Mansonoides*) *dives* and *An. sundaicus* were reported to bite the aborigine tribes in the jungles of Nancowry group of Nicobar Islands[15]. Only one specimen of *Do. nivea* was naturally found infected, but none was found with infective stage (L_3) larvae. The role of *Ae. scutellaris* which is an established vector in Thailand[8] and Singapore[23,24] could not be ascertained by Kalra[15]. Thereafter, Russel and his co-workers[16] in the same group of islands (Kamorta), reported natural infection in *Cx. quinquefasciatus* collected from human dwellings. One of 150 mosquitoes was found to harbour L_3 stage larvae, indicating the probable co-existence of both periodic and subperiodic forms of *W. bancrofti* in Nancowry group of islands. However, during this study, established vectors of DspWB were not studied. After considerable lapse of time, Tewari *et al*[9] showed that aborigine tribes entering the forests were

commonly bitten by *Do*. *nivea* and *Ae*. *scutellaris*. *Do. nivea* was found naturally infected with *W. bancrofti* with infection and infectivity rates of 1.1 and 0.9 per cent, respectively. *Cx*. *quinquefasciatus* was recorded in very low densities and none was found infected.

Experimental infection studies by allowing mosquitoes to feed on *mf* carriers of *W*. *bancrofti* from Nancowry and Chowra (showing *mf* both in day and night time blood samples) and Port Blair (periodic form) showed the development of *mf* to L_3 only in *Cx*. *quinquefasciatus*[16]. The *mf* were observed to develop into L_2 and L_3 stages after 14 days post infection. The mean number of infective larvae (L_3) per mosquito did not differ significantly in Chowra and Nancowry, though there were significant differences in *mf* densities among carriers. However, in Port Blair the mean number of L_3 per mosquito was significantly higher than that observed with *mf* carriers from Nancowry and Chowra. Only a few mosquitoes of the species *Ae*. *scutellaris* were fed on *mf* carriers and reported dead within 2-3 days after the infective blood meal[16].

Similar studies[9] with female mosquitoes of *Do*. *nivea*, *Ae*. *malayensis* and *Ae*. *aegypti* fed simultaneously on *mf* carriers from Chowra (DspWB) in two batches were carried out. The first batch of mosquitoes were fed on a carrier with 206 *mf*/20 µl, and a second batch on carriers with 300 *mf*/20 µl blood at the time of feeding. *Do*. *nivea* was the only species in which larvae of *W*. *bancrofti* were developed L_1 stage was found on 2-4 days post-infection, L_2 larvae from day nine onwards and L_3 larvae on day 13. *Ae*. *malayensis* and *Ae*. *aegypti* were found to pick up *mf* but did not support the development of the parasite.

Do. nivea is an established vector of the DspWB in Nancowry islands, Nicobar district. Though the members of *Ae*. *scutellaris* subgroup known as vector elsewhere[9,23,24], are prevalent in the Nancowry group of islands[11,12,15,16,21], their role in the transmission needs verification. All the earlier entomological investigations were based on point surveillance. To understand the transmission dynamics it is essential to generate data from long term studies. Such studies would also be useful to enlist the mosquito fauna, their population dynamics and breeding habitats.

Advances in the understanding of DspWB

Clinical epidemiology and assessment of true mf prevalence: In view of undertaking studies on transmission dynamics, the Regional Medical Research Centre (RMRC), Port Blair, initiated studies to assess the prevalence of *mf* and to examine the frequency distribution of DspWB *mf* in one of the remotely located Teressa Island in the Nicobar district. The overall endemicity rate observed was 17.1 per cent. *Mf* carriers were found in all the 11 villages in this island with *mf* rates ranging from 5.11 to 25 per cent. *Mf* rate increased gradually with age, reaching a peak in the age class 31-40 yr and thereafter showed a decreasing trend. *Mf* rate and disease rates were significantly higher in males (14.7 and 5.2%, respectively) than females (8.6 and 1.5%, respectively). Acute disease occurred only in the age group of 40 yr and above, with a prevalence of 1.2 per cent[25]. The negative binomial distribution fitted to the data on distribution of mf counts gave a perfect fit. The data having been fitted to the negative binomial, the expected *mf* prevalence could be determined as 16.82 per cent as against an observed prevalence of 11.83 per cent[26].

Mosquito species diversity, vector status, infection and infectivity in vector mosquito: At least 12 species of mosquitoes were found biting the native aborigine tribe. *Do*. *nivea* predominated among the mosquitoes from man landing collections. The percentage of *Do*. *nivea* in the total biting mosquito population was 89.7 per cent followed by *Ae*. *malayensis* (3.4%). Among the 12 species of mosquitoes dissected, only *Do*. *nivea* was found to be naturally infected with *W*. *bancrofti*. Infection was observed to be perennial whereas the infectivity was seen during most part of the year, barring February, July and August. The results confirm active transmission by *Do*. *nivea*[27].

Circadian rhythm of human biting activity and transmission of DspWB by Do. nivea: Biting activity of *Do*. *nivea* was seen throughout the day, exhibiting a bimodal peak, with the first one at dawn (0400-0600 h) and the other towards the dusk hours (1600-1800 h). The proportion of mosquitoes biting in the forenoon was 40.4 per cent whereas in the afternoon it was 59.6 per cent. This was true for both parous (42.0 vs. 58.0%) and nulliparous mosquitoes (39.9 vs 60.1%). However, the risk of transmission of filariasis due to *Do*. *nivea*, based on parity status was found to be during the dawn (0400h) and dusk (1600-1800) hours[27]. The circadian rhythm of the DspWB *mf* [9] is in agreement with the biting rhythm of the vector, *Do*. *nivea*[27], enabling the vector mosquito to ingest a large numbers of *mf* by presenting themselves in large numbers in the peripheral blood during the peak biting period.

Transmission dynamics of DspWb vectored by Do. nivea: Comprehensive studies on transmission

dynamics of DspWB through yearlong observations covering different seasons were undertaken[28]. The number of vectors biting a person in a year was estimated to be 21851, of which 107 were harbouring infective parasite. Risk of infection intensity was 0.02332. Every person in this study area was at the risk of receiving an estimated number of 22 infective stage larvae per year. The host efficiency index of *Do*. *nivea* indicated that over 40 per cent of the *mf* ingested were able to develop into infective stages. The index varied between 0 and 0.88 during different months of the year. The annual transmission potential (ATP) was 169 with evidence of year round transmission. The pattern of monthly transmission potential suggested that the intensity of transmission was high during summer months. Perennial transmission of subperiodic *W*. *bancrofti* in the typical forest ecosystem was evident with transmission parameters suggesting summer as a high risk season for transmission[28].

Bioecology, population dynamics, age composition and survival in relation to transmission: Growth and/or development rates, and survival and fecundity at different ages in relation to space and time, are important in understanding population dynamics of a vector mosquito. Age composition, mosquitoes that had laid eggs at least once, finite rate of natural increase (λ) and vector survival reflecting the population dynamics of *Do*. *nivea* in relation to transmission of filariasis were estimated[29]. Changes in finite rate of increase (λ>1) during favourable months indicate an increase in the vector population, suggesting the need for intensified intervention. The proportion of mosquitoes completing more than one gonotrophic cycle was higher in months when λ was 1. *Do*. *nivea* abundance and its parous densities varied with seasons. Survival of *Do*. *nivea* (indicated by the proportion of parous mosquitoes) was lower in the pre-monsoon season than during the monsoon and post-monsoon seasons. The probability of the daily survival of *Do*. *nivea* through one gonotrophic cycle was 0.75, with a declining trend as age increased[29].

Density dependent constraints - mortality of vector and parasite loss: The *mf* load in the community has implication on the parasite load in the vector. Keeping this in perspective, the density dependent parasite mortality and survival probability of the parasite in *Do*. *nivea* were studied. Distribution pattern of various filarial larval stages suggested that the loss of parasites occurred as development progressed and was maximal between the L_1 and L_2 stages. Further, both the prevalence of infection and the degree of parasite aggregation in *Do*. *nivea* fell significantly with development of parasite stage, indicating the operation of parasite density dependent mortality of vectors or parasite loss or combination of both[30].

Elimination strategy for lymphatic filariais

In consonance with the Global Programme to Eliminate LF (GPELF), a programme has been initiated in 2012 to realize the National Health Policy of India (Ministry of Health and Family Welfare, 2002)[31] to eliminate LF by 2015. The key strategy is to distribute single-dose DEC with albendazole (alb) to all individuals annually for at least 4-5 years (mass drug administration programme) . Currently, the elimination programme is underway in 250 districts spanning 20 States and Union Territories. In the Andaman and Nicobar Islands, the programme to eliminate LF was launched in 2004 by the Directorate of Health Services, Andaman and Nicobar Administration, implying that DspWB would also be eliminated. Currently, the islands endemic for DspWB along with other islands endemic for NpWB have received nine rounds of MDA. DEC alone was used in the first four rounds and it was co-administered with alb in the subsequent rounds of MDA (NVBDCP, A&N Islands, personal communication).

Post-MDA research findings

Post-MDA-I survey results in one of the endemic islands (Teressa) for DspWB filariasis showed *mf* prevalence ranging between 3.2 and 23.1 per cent in different villages with a mean parasite intensity of 37.31 (range 1-492)/60 µl among the microfilaraemics[32]. *Mf* prevalence and geometric mean intensity (GMI) of *mf* densities did not differ significantly between pre-MDA and post-MDA-I. The zero truncated negative binomial distribution model fitted to the data indicated to be a good fit for both pre- and post-MDA *mf* count distributions. The estimated 'k' (the degree of parasite aggregation) values for pre-MDA (k= 0.18, 95% CI= 0.018-0.37) and MDA-I (k= 0.23, 95% CI= 0.10-0.38) did not differ significantly (95% CI for 'k' overlap). This suggested that the degree of parasite aggregation was not different between pre- and post-MDA[32]. The GMI of *mf* in 2000 (pre-MDA) and 2005 (MDA-I) did not show any significant difference between pre and MDA-I[32].

Ending 2011, six rounds of MDA had been completed covering three districts *viz*. North & Middle, South Andaman and Nicobar district with a population

of 3,84032. Monitoring *mf* prevalence is carried out as a part of the programme implementation in sentinel and spot check sites and all the sites have been reported to have <1 per cent *Mf* prevalence (NVBDCP, A&N Islands, personal communication,). However, none of the sentinel or spot check sites represented DspWB endemic islands and, therefore, the impact of MDA on DspWB was undertaken by the RMRC, Port Blair, to examine its eligibility for transmission assessment survey (TAS). The overall *mf* prevalence was 3.28 per cent. Except one island, all other islands recorded *mf* prevalence >1 per cent, ranging from 2.5 to 5.3 per cent, indicating persistence of infection post six annual rounds of MDA. *Mf* prevalence was age dependent and was higher among males, but not significantly different between genders. Age and gender specific analysis showed a significant reduction in all the age classes among females *vis-a-vis* pre-MDA prevalence while the reduction was significant only in 21-30 and 41-50 age classes in males. Exposure to day biting and forest dwelling *Do*. *nivea* could be attributed for the persistent infection besides non-compliance for MDA. Based on fits of modified negative binomial distribution, true prevalence of *mf* carriers in the community was estimated to be 4.74 per cent, which was markedly higher (about 24%) than the observed prevalence of 3.28 per cent[33]. Follow up of cohorts showed evidence of continued persistence of infection and acquisition of new infections post six rounds of MDA. As the *mf* prevalence was above >1 per cent in four of the five islands, this area was not eligible for TAS, warranting continuation of MDA[33].

Eight rounds of MDA had been accomplished by 2012. A first systematic and independent effort was undertaken by the RMRC, Port Blair to assess the coverage and compliance post MDA-VIII in the ongoing LF elimination programme in these islands. A total of 2732 people were interviewed from the rural and urban areas of the three districts[34]. In this assessment, high drug coverage was observed in all three districts of the A & N Islands. The overall coverage was 91.4 per cent, while consumption/compliance was 89.8 per cent. The highest coverage was seen in the Nicobar district. Distribution, compliance and effective drug coverage rates were higher in Nicobar district compared with the other two districts. About 10 per cent of the respondents were non-compliant and the major reasons were that the drug distributor had not visited the house and the fear of the side effects[34]. Compliance rate ranged between 91 per cent (Katchal) to 100 per cent (Chowra, and Teressa). The overall effective drug coverage was 90.8 per cent, implying that 90.8 per cent of the population residing in the Nancowry group of islands had consumed the drug. Effective drug coverage in different islands ranged between 83.7 per cent (Katchal) to 100 per cent (Chowra and Teressa)[34]. This assessment indicates that maximum efforts have been accomplished to achieve these levels of distribution, compliance and effective drug coverage in the ongoing LF elimination programme.

Challenges to the current elimination strategy

Despite six rounds of MDA, DspWB LF still persists among the Nicobarese. In view of its risk of spreading from the lone endemic focus to other areas that are currently non-endemic for this infection, but receptive with competent vector, it is essential to hasten the process of elimination of this infection. Eliminating DspWb in the Nicobar district is challenging including remoteness, vector-parasite combination and persistence of infection. There is evidence of persistence of LF in a *Do*. *nivea* vector endemic area and has significant implications for the LF elimination in Nancowry Islands, Nicobar district and other similar settings where day biting vector is endemic[33]. Spatial clustering and persistence of infection have also been documented in areas vectored by *Ae. polynesiensis*[35]. This poses a challenge in such vector endemic settings when transmission levels are at low ebb[36]. Further, efforts may not be useful as the compliance is already above 90 per cent. We believe that elimination can be achieved with additional control pressure, as an adjunct to the current strategy of mass annual single-dose treatment.

How do we approach this issue *vis-a-vis* persistence of DspWB in Nancowry Islands?

Annual single-dose two-drug regimen (alb plus either DEC or ivermectin) or six months to a year of DEC-medicated salt[37] has been recommended for the elimination of LF. DEC medicated salt has been proved to have played a key role in the LF control programmes world over[38]. The first reported use of DEC-medicated salt was in Brazil in 1967, by Hawking, who first identified antifilarial properties of DEC in the 1940s[39]. Since then, it has been used intermittently in India, Africa, and Asia. The efficacy of DEC medicated salt was first assessed in close communities[40-42]. Subsequently, small and medium scale trials using 0.1 to 0.26 per cent fortified salt were undertaken in India and other countries. The results of these trials in India and elsewhere proved to be very

encouraging and *mf* density dropped by more than 90 per cent and *mf* disappeared from the blood in 31 to 98 per cent of the infected population[43-48]. Similar effects have been obtained from medium scale trials, covering population in the range between 1000 and 7000[49-54] and one large scale trial covering a whole endemic province with a population of over two million in China where the problem was as serious as in India[54]. The *mf* prevalence declined by 96 to 98 per cent and *mf* density by 87 to 99 per cent. In another study, it was reported that the rates of medication, cure, *mf* reduction and infection in vector were 100 per cent with no refusals or excuses[55]. In 1998, DEC fortified salt was used in Kanayakumari district, Tamil Nadu to control bancroftian filariasis[56]. DEC salt was fortified and supplied by the Salt Corporation of India. DEC salt was distributed through government owned public distribution system. However, the coverage was between 30 and 35 per cent[56]. Evaluation of the programme using antigenaemia and *mf* prevalence showed persistence of infection. Low coverage and compliance was attributed for achieving the desired level of reduction. Subsequently, this district was covered under National Filariasis Elimination Programme. Since the first reported use of DEC fortified salt in 1967 and its usage in India and elsewhere, only mild or no side reactions were reported. Thus it is evident that mass treatment with DEC fortified salt has been used in a number of locations as a control measure for the control of LF and reported to be safe for community use. A systematic review of the studies on the effects of DEC fortified salt in LF evaluated through individual and community based trials has shown the usefulness of DEC fortified salt in controlling LF[57]. Thus, DEC-fortified salt provides an operationally viable alternate/adjunct option to the ongoing MDA and has the potential to overcome the challenges to the current elimination strategy and it can hasten the process of interrupting/eliminating transmission in areas having persistent foci in a cost-effective manner, than tablet-based programmes[58].

Perspective of vector control and putting in place a DEC fortified salt strategy in the Nancowry islands, Nicobar district

From the perspective of vector control programme, which could reduce or eliminate transmission in endemic territories, it is a difficult proposition and may prove to be cost-prohibitive, since vector control measures are very difficult owing to their exophily and diurnal feeding behaviour. Further, the larvae are not amenable to larvicidal measures because of many scattered, peculiar and inaccessible breeding habitats of the mosquitoes[28-30]. Personal protection measures (use of repellent creams) may be useful for protecting from the risk of transmission. But the affordability of tribal community at the risk will be a major limitation. Typical eco-geographical location of the island situation with closed communities and the tribal chieftains wielding enormous control over the community augur well for putting in place a rational strategy for tackling this problem. In such epidemiological settings, the potential alternative method of eliminating this infection may possibly be the use of DEC fortified salt where the inflow of conventional salt can be controlled. Therefore, the situation in the Andaman and Nicobar archipelago presents an ideal scenario to demonstrate the administration of DEC fortified salt for eliminating the lone foci of DspWB filariasis from India[59].

***Modus operandi* for achieving the goal of eliminating the lone focus of DspWB in India**

The infrastructure available with the Directorate of Health Services, Andaman and Nicobar administration, provides us an opportunity to align the distribution of DEC fortified salt along with the ongoing MDA and other intervention programmes. The Andaman and Nicobar administration, in particular the Deputy Commissioner (DC) of Nicobar district and Assistant Commissioner (AC) of Nancowry Tehsil, have magisterial powers and administrative jurisdiction over the pockets of islands endemic for DspWB. Besides, the AC is in-charge of departments like supply, shipping, transport, *etc*. in addition to Revenue, Development and Law and order in the area of jurisdiction. Nicobar district is designated as Integrated Tribal District, with DC as the *ex officio* Chairman of Integrated Tribal Development Agency (ITDA)[60]. The various poverty alleviation programmes sponsored by the Ministry of Rural Development are being implemented through District Rural Development Agency (DRDA), headed by the DC. The Tribal Councils in the Nicobar district are pivotal, around which various developmental schemes for the welfare of the tribal people revolve. Every village in the tribal area has a village council headed by Tribal Captains. Every island/group of islands has in place a Tribal Council, constituted by the first Captains of Village Councils falling in their jurisdiction. The Tribal Council and their Captains provide the linkage between the Andaman and Nicobar administration and the tribal people of the island. All these elements have been sensitized and are being involved in assisting the elimination of this form of LF[60].

Conclusion

Persistence of infection with >1 per cent *mf* prevalence in the lone focus of DspWB is evident. Therefore, additional intervention pressure becomes inevitable. Either mass DEC-fortified salt or vector control measures can be considered as options and need to be supplemented for strengthening the effect of the ongoing MDA and to hasten the process of elimination of *Culex* transmitted NpWB infection. However, in the present scenario, neither vector control nor personal protection such as use of repellents is feasible due to unique vector behaviour and cost-prohibitive personal protection measures. Typical eco-geographical location of the island situation with closed communities, well-organized public health infrastructure, and public distribution system in these islands look promising for putting in place a mass DEC-fortified salt strategy. The challenges of elimination of DspWB will remain, but targeted and well-managed DEC-fortified salt programme may provide significant opportunities beyond the focus of the elimination of this infection. Addressing the agenda revolves around the partnership built and commitment from different stakeholders, which envisages a platform for a productive alliance between the tribal council/village council and the Directorate of Health Services, A & N administration.

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