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Review Article

Soil-Transmitted Helminth Infection in General Population and Schoolchildren of Bali: A Review

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ABSTRACT

Soil-transmitted helminth infection is endemic in Bali, affecting adult people and preschool-age and school-age children. Surveys done during 1979-2000 on different groups of people in urban and rural places of Bali have found quite a high infection prevalence of *Ascaris*, *Trichuris*, and hookworm. Surveys carried out during 2002-2010 on elementary school children in rural villages of Badung and Gianyar districts have also found a similar high prevalence of *Ascaris*, *Trichuris*, and hookworm. Intensity of infection of *Ascaris* and *Trichuris* in elementary schoolchildren was mostly light to moderate, but a portion of the schoolchildren had heavy infection with the two species. A survey done on elementary schoolchildren that were found infected with *Ascaris* and *Trichuris* has shown reinfection of *Ascaris* occurred two months and three months, respectively, after anthelmintic treatment, while reinfection of *Trichuris* occurred one month, two months, and three months, respectively, after anthelmintic treatment. The high prevalence and reinfection of STH indicate poor hygiene-sanitation of the rural communities that causes persistent pollution of soil with infective STH eggs. In the villages where we did the surveys, we found many households did not possess latrine and water supply, which was due to poverty. We stress the importance of regular prevention and control programs of STH infections particularly for elementary school children that should be jointly undertaken by the Bali provincial government and the central government, in the forms of regular anthelmintic treatment, health education, and improvement of hygiene sanitation.

Keywords: Soil-transmitted helminth infection; Elementary schoolchildren; Prevalence; Infection intensity; Reinfection; Bali

INTRODUCTION

Soil-Transmitted Helminths (STH) are a group of intestinal nematodes that need soil for the development of their eggs to become embryonated eggs or infective larvae that can cause infection in humans by ingestion of the eggs or skin penetration by the larvae [1]. The STH species that commonly infect humans are *Ascaris lumbricoides*, *Trichuris trichiura*, *Ancylostoma duodenale*, *Necator americanus* (both called hookworm), and *Strongyloides stercoralis*. *Ascaris lumbricoides*, hookworm, and *Strongyloides stercoralis* inhabit the small intestine, while *Trichuris trichiura* inhabits the cecum and ascending colon. Adult female worms produce eggs which are passed out with stool and reach the soil when the infected subject defecates outside the latrine. Eggs of *Ascaris* and *Trichuris* mature or become embryonated in soil but do not hatch. Hookworm eggs hatch in the soil to transform into non-infective rhabditiform larvae and subsequently into infective filariform larvae. Strongyloides eggs hatch in the intestine as rhabditiform larvae and passed out with stool which then transforms into infective filariform larvae or instead becomes free-living adults in soil. Filariform larvae of *hookworm* and *S. stercoralis* penetrate the human host's skin and enter the circulation. Embryonated eggs of *Ascaris* and *Trichuris* when digested by the human host release larvae in the small intestine. Larvae of *Trichuris* become adults in the colon, while larvae of *Ascaris* penetrate the intestinal mucosa and enter the blood circulation, and are carried to the lungs. Larvae of *Ascaris* and hookworm that have entered the lungs penetrate the alveolar wall, then ascend to the throat and swallowed. Once they reach the small intestine, they subsequently grow into adult worms. As mentioned above, rabditiform larvae of *S. stercoralis* that are passed out with stool can develop into filariform larvae in soil which penetrate the host's skin and subsequently follow the bronchial migration, or may undergo the free-living phase of its life. In its free-living cycle, the adult worms produce eggs from which rhabditiform larvae hatch which then become infective filariform larvae that can penetrate the human host's skin [2,3].

Worldwide soil-transmitted helminth infections are the most

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common helminthic infections in humans. *Ascaris*, *Trichuris*, and hookworm are highly prevalent in many tropical and sub-tropical regions of the world, in particular Southeast Asia [1,3-11]. It is estimated that nearly a quarter of the world's population is infected by one or more species of the STH. The most prevalent species *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm are estimated to have infected around 800 million-1200 million, 600 million-800 million, and 500 million-700 million people, respectively [9,10]. It is estimated also that around 270-600 million preschool-age children and school-age children are continually exposed to the risks of being infected because they live in highly STH endemic areas [11,12]. Globally it is well-documented that elementary school-age children (6 to 12 years of age) are most frequently infected by STH, especially by *Ascaris* and Tricchuris [4,6,9,10,13]. Several studies carried out in different places in Indonesia have confirmed the endemicity of STH infections both in children and adults [6,12-26]. In Indonesia, it is estimated that around 195 million people including 13 million preschool-age children and 37 million school-age children live in areas endemic for STH infections [27].

Bali, which is one of the 33 provinces of Indonesia, is a small island located in the tropical zone of the globe at 115° 42' East by 8° 50' South, with an area of about 5600 km^2 [28]. Bali's population is 4.15 million who mostly lives in rural areas as farmers [6,29,30]. Administratively, Bali is divided into eight districts, namely: Buleleng, Jembrana, Tabanan, Badung, Gianyar, Bangli, Klungkung, and Karangasem, while Denpasar is the capital city, located in Badung district (Figure 1) [29].

Topographically, Bali consists of lowlands (0-500m) and highlands (>500 m), each of which covers about half of the island. The annual rainfall is high in the southern lowlands and highlands and a little lower in the northern lowlands. Bali's tropical climate with moderate temperature and high humidity makes the soil remains moist and warm all year round in most areas of the island [31]. This climatic condition together with poor personal hygiene and environmental sanitation are favorable for the STH life cycles which eventually cause a high prevalence of STH infections in the community [2,3,9].

This review aims to discuss the problems of STH infection in the general population and elementary school children in Bali, with reference to prevalence, worm species, infection intensity, treatment, reinfection, factors of hygiene-sanitation, and perspectives towards prevention and control strategies.

PREVALENCE OF STH INFECTION IN DIFFERENT GROUPS OF POPULATION IN BALI

During the period of 1979 to 2000, surveys have been carried out by several workers in several urban and rural villages located throughout Bali. Data of results of the surveys are summarized in Table 1.

The data in Table 1 indicate that STH infections are endemic in Bali, affecting people of all ages and consistently involving the species *Ascaris*, *Trichuris* and *hookworm*. Generally, except in few places, *Ascaris* had the highest prevalence (30.6%-91.3%), followed in order of decreasing percentage by *Trichuris* (13.8%-89.9%) and hookworm (3.3%-72.5%). In the general population, infections with *Ascaris* and *Trichuris* appeared to be evenly distributed with

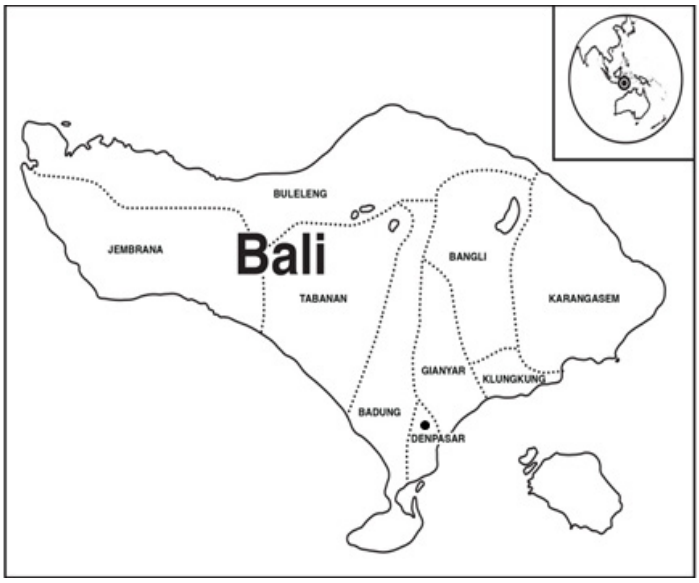

Figure 1: Map of Bali showing its approximate location in Indonesia and its eight districts and the capital city of Denpasar.

Table 1: Prevalence of soil-transmitted helminth infections according to surveys done in Bali on different groups of the population, by locations and species, 1979-2000.

Workers, Year	Locations (rural/urban)	Type of population studied	No. fecal samples examined	% Species positive		
				Al	Tt	Hw
Rasidi et al., 1979	Padangsambian, Badung district (rural)	All ages	208	91.3	89.9	54.8
	Sukawati, Gianyar district (rural)	All ages	199	90.4	78.4	44.2
	Trunyan, Bangli district (rural)	All ages	131	84.7	41.2	30.5
Bakta et al., 1979	Sanglah Hospital, Denpasar (urban)	Adult hospitalized patients	156	40.7	25.8	23
Sutisna et al., 1980	7 elementary schools, Badung district (rural and urban)	Elementary schoolchildren	324	95.9	60.5	19.2
Bakta et al., 1981	Kedisan, Gianyar district (rural)	All ages	171	77.8	64.3	72.5
Suryadhi et al.,1982	All over Bali (rural)	Under 5-year-old children	1216	59.7	13.8	3.3
Bakta et al., 1986	Br. Saba, Penatih village, Badung district (rural)	Adults	164	85.4	88.4	42.7
Sutisna et al., 1999	Pamesan and Batuan village, Gianyar district + Penarukan village, Tabanan district (rural)	All ages	415	30.6	34.7	8.4
Widjana and Sutisna, 2000	All over Bali (rural)	All ages	2394	73.7	60.6	24.5

Tt: *Trichuris trichiura*; Hw: *Hookworm* Al: *Ascaris lumbricoides*

Table 2: Prevalences of soil-transmitted helminth infection in elementary schoolchildren in Badung and Gianyar district, 2003-2010.

Locations (district/village)	No. of individuals surveyed	No species positive (%)			Reference
		Ascaris	*Trichuris*	Hookworm	
Urban Denpasar City	4858	176 (3.6)	307 (6.32)	3 (0.1)	PKBI Bali, 2003
RuraL Badung District					Kapti et al., 2002
Jagapati	255	108 (42.3)	159 (62.3)	5 (1.9)	
Punggul	218	167 (76.6)	173 (79.3)	9 (4.1)	
Penatih	138	72 (52.2)	84 (60.9)	0 (0)	
Rural Badung district:					Kapti et al., 2003
Belok Sidan	71	47 (66,2)	27 (38.0)	4 (5,6)	
Taman	92	65 (70.6)	75 (81.5)	12 (13.0)	
Mambal	89	40 (44.9)	68 (76.4)	0 (0)	
Sibang Kaja	175	52 (29.7)	87 (49.7)	0 (0)	
Rural Badung district:					Kapti et al., 2005
Bongkasa	212	118 (55.7)	177 (83.5)	0 (0)	
Rural Badung district:					Kapti et al., 2007
Plaga	602	132 (21.9)	72 (12.0)	45 (7.5)	
Belok Sidan	546	119 (21.8)	87 (15.9)	13 (2.4)	
Rural Gianyar district:					Kapti et al., 2010
Keramas	308	61 (19.8)	175 (56.8)	0 (0)	
Tulikup	565	19 (3.4)	109 (19.3)	1 (0.2)	

somewhat equal high prevalence in urban, semi-urban, and particularly in rural areas, while the prevalence of hookworm infection was higher in rural villages than in semi-urban or urban areas (Denpasar city and surroundings). It was also found that children under five years of age (pre-school age) were readily infected by *Ascaris*, *Trichuris*, and hookworm. These findings also indicate that in almost all regions of Bali, especially in rural villages, the condition of hygiene and sanitation was poor, which favors the continual transmission of STH infections among the people.

PREVALENCE OF STH INFECTION AMONG ELEMENTARY SCHOOLCHILDREN

During the period of 2004-2012 surveys were carried out on STH infections among elementary schoolchildren in some urban and rural areas of Badung and Gianyar districts by the Department of Parasitology, Udayana University, and the Department of Microbiology and Parasitology, Faculty of Medicine and Health Sciences, Warmadewa University. Results of the surveys are summarized in Table 2.

Table 2 shows that in rural areas such as in the villages of Taman, Mambal, Sibang, Plaga, Ayunan, Bongkasa, Belok Sidan (in Badung district), the prevalence rates of STH infection in elementary schoolchildren were somewhat equally high as those in the general population (Table 1), with the species *Ascaris*, *Trichuris* and hookworm as the causes. The prevalence rates of STH infection in elementary schoolchildren in Keramas and Tulikup villages (in Gianyar district) appeared to be lower than those in rural Badung district, however, *Ascaris*, *Trichuris*, and hookworm were similarly involved. The apparently much lower prevalence rates in elementary school pupils in Denpasar city are likely due to better personal hygiene and environmental sanitation in this capital city as well as due to more regular deworming employed to the pupils of the elementary schools surveyed through the program of "Usaha Kesehatan Sekolah" or School Health program. Similar reason might also apply regarding the low prevalence rates of STH infection in elementary school pupils in Keramas and Tulikup villages (both located close to Gianyar city, the capital of Gianyar district); besides both villages are included under the community health care program of the Warmadewa University Faculty of Medicine where periodic health education and anthelmintic treatment were given to the pupils.

SINGLE SPECIES INFECTION VS MULTIPLE SPECIES INFECTION

In some of the surveys as summarized in Table 1 and Table 2, assessments were made of whether the infected persons harbored a single infection (infection with one species) or multiple infections (infection with more than one species). Bakta et al. reported that of adult persons infected with STH, 20% had a single infection and 80% had multiple infections that mostly consisted of the combination of *Ascaris* and *Trichuris* [19]. Bakta et al. in a study on 2,331 people all over Bali found 24.02% (560/2331) were infected with *hookworm* [32]. Of the 560 cases of *hookworm* infection, 61% were associated with *Ascaris* and *Trichuris* (triple infection), 7.7% with *Ascaris* (dual infection), 16.3% with *Trichuris*, and only 5.5% as a single infection with *hookworm* alone. In a study on people of all ages all over Bali, Widjana and Sutisna found of 2082 persons infected with STH, 33.1% had a single infection (mostly with *Ascaris*) and 66.9% had multiple infections comprising 47.8% with *Ascaris* and *Trichuris* (dual infections), 18.3% with *Ascaris*, *Trichuris* and *hookworm* (triple infections), and 0.8% with *Ascaris*, *Trichuris*, *hookworm*, and Strongyloides (quadruple infections) [6]. Kapti et al. in a survey on elementary school pupils in Sibang Kaja, Mambal, and Taman villages found 44.8% was single infection with either *Ascaris* or *Trichuris* and 45.2% was multiple infections with the combination of *Ascaris* and *Trichuris* [22]. The occurrence of multiple infections besides single infections indicates that the

infective forms of STH species, particularly eggs of *Ascaris* and *Trichuris*, are widely spread in the soil in the rural villages and act as sources of infection for the people.

INTENSITY OF INFECTION

Intensity of STH infection in people of all ages

Few studies have been done in Bali to evaluate the intensity of the STH infections. Bakta et a1. in a survey in Penatih village in Badung district assessed the infection intensity of adult people found infected with STH by counting the number of Eggs Per Gram of stool (EPG) by modified Kato-Katz thick smear technique [19,33]. Results of the EPG counting showed an average EPG of 3570 for *A. lumbricoides*, 655.4 for *T. trichiura*, and 1118.8 for *hookworm*. Using the criteria described by Khan, they classified the infection intensity of *A. lumbricoides* and *T. trichiura* as light and moderate infection, respectively, and the infection intensity of hookworm as light [34]. Widjana and Kapti evaluated the infection intensity of 143 people infected with *Ascaris* in Br. Pande, Renon village in Denpasar city and found 63.6% had a light infection, 30.8% moderate infection, and 5.6 % severe infection [35]. They also found that infection intensity was significantly higher in the younger carriers (up to 13 years of age), in the carriers with low-education status, and in carriers who did not have latrines in their households.

Intensity of STH infection in elementary schoolchildren

Data are also limited of STH infection intensity among elementary school children in Bali, however, the available data may represent the actual condition since they were obtained from surveys done both in urban and rural settings. Kapti et al. evaluated the infection intensity of 259 schoolchildren found infected with STH in three elementary schools at the rural villages of Taman, Mambal, and Sibang Kaja in the Badung district [22]. Among the schoolchildren infected with *Ascaris*, 77.7% of the infection was light intensity (EPG 2107), 14.7% moderate (EPG 2475), and 7.6% heavy (EPG 102475). Of the *Trichuris* infected children, 84.8% was very light intensity (EPG 246), 12.2% light (EPG 1883), 2.6% moderate (EPG 5789), and 0.4% heavy (EPG 11180). From the above findings, it can be concluded that most of *Ascaris* and *Trichuris* infections in the elementary schoolchildren were light and moderate, but it should be noted that a portion of the elementary schoolchildren infected with the two species had heavy infection intensity.

ANTHELMINTIC TREATMENT TRIAL

A trial with Mebendazole and Pyrantel pamoate was carried out by Rai [36]. Sixty confirmed STH infected subjects were given Mebendazole at a dose of 100 mg twice a day for three consecutive days and 60 other infected subjects were given a single dose of 750 mg Pyrantel pamoate. Mebendazole gave a cure rate of 98.1% for *A. lumbricoides*, 92.7% for *T. trichiura* and 88.4% for *hookworm*. Pyrantel pamoate gave a cure rate of 96.6% for A. lumbricoides, 22.6% for *T. trichiura*, and 81.6% for *hookworm*. Side effects of the two drugs were minimal and transient. It was concluded that Mebendazole and Pyrantel are equally effective for *Ascaris* and hookworm infections, but Pyrantel is less effective than Mebendazole for treating *Trichuris* infection.

Kapti et al. assessed the efficacy of a combination of 10 mg Pyrantel and 10 mg Oxantel (Quantrel^{R}) for treating *Ascaris* and *Trichuris* infections in elementary school children [37]. Result of the treatment was evaluated two weeks after administration of the drugs where "cure" was confirmed if microscopically no more STH eggs were found in the fecal sample. The combination of Oxantel-Pyrantel was given 10 mg/kg BW for one day for children infected with *Ascaris* and *Trichuris*, respectively of 69 cases of Ascariasis treated, Oxantel-Pyrantel gave a cure rate of 96.9%, and of 109 cases of Trichuriasis treated, it gave a lower cure rate of 63.5%. On another series of treatments, they used Albendazole for *Ascaris* and *Trichuris* infections, respectively. Albendazole given in a single dose of 400 mg for one day to 50 children with Ascariasis gave a 96.0% cure rate, while Albendazole with the same dose given to 79 cases of Trichuriasis gave a much lower cure rate of 39.2%. With 400 mg Albendazole given for two consecutive days to 80 children with Ascariasis they found a cure rate of 100%, while of 98 children with Trichuriasis the cure rate was 93.0%. No recognizable side effects were noted from the three regimens of drugs. It was concluded that the combination of Oxantel-Pyrantel in a single dose was more effective for Ascariasis than for Trichuriasis, and Albendazole in a single dose of 400 mg for two consecutive days was more effective for treating Ascariasis and Trichuriasis than 400 mg Albendazole given for one day only. No treatment assessment was carried out on *hookworm* because the positivity of *hookworm* infection in the schoolchildren was very low.

REINFECTION OF STH INFECTION AMONG ELEMENTARY SCHOOLCHILDREN

The data available on this issue are derived only from the results of a single study done by Kapti et al. on elementary school children in the villages of Taman, Mambal, and Sibang Kaja in Badung district [38]. Two hundred and forty-six (246) schoolchildren found positive for *Ascaris* and *Trichuris* infections by Kato-Katz fecal thick smear were treated with anthelmintic drugs, and on examination of their stools 2 weeks after treatment it was found that 236 of the 245 (95.6%) treated children were cured (no worm eggs found in the stool). Stool samples of the 236 cured schoolchildren were recollected and examined each month for three consecutive months after cure to find out if reinfection occurred by finding *Ascaris* and or *Trichuris* eggs in the stool. It was found that reinfection of *Trichuris* occurred at the rate of 4.6%, 7.6%, and 20.9% one month, two months, and three months after cure, respectively, Reinfection of *Ascaris* occurred at 1.3% and 10.9% two months and three months after cure, respectively. Reinfection of the two STH species indicates that the source of infection i.e. the infective eggs of *Ascaris* and *Trichuris* continued to exist in the soil and hence acted as a source of infection for the children. This condition is favored by the poor hygiene and sanitation condition in the villages where many children and adult people defecate indiscriminately on the backyards of houses, fields, or streams because most of them do not possess latrines in their households. School-age children commonly have the habit of playing on the ground and because they are careless about their personal cleanliness and hygiene (e.g. not washing hands before eating, and eating and drinking out within poor hygienic conditions), they become continually exposed to the risk of being infected after curing by anthelmintic treatment. It is well known that because of their thick egg walls, eggs of *Ascaris* and *Trichuris* are resistant to heat, thus enable them to remain viable in the soil for a relatively long time causing persistent and higher prevalence in areas with poor hygiene-sanitation. In people harboring the worms but left untreated, reinfection can cause more severe infection intensity i.e. greater number of worms inhabiting the intestine [2,3,6,9,12].

HYGIENE AND SANITATION AND OTHER FACTORS ASSOCIATED WITH STH INFECTION

Some of the main factors closely associated with STH infection

are the availability of latrines in households, personal hygiene, and environmental sanitation, health-related behaviors such as washing hands before eating, boiling drinking water, hygienic handling of food, and level of knowledge of how infection with STH can occur [3,12].

Availability of latrines in households in Bali

A survey done in 1999 covering populations all over Bali found that in rural areas only 35% of households had latrines, while in urban areas 73.1% of households had latrines [6]. In later years sanitation conditions in Bali appeared to have improved. For the year 2014, the overall level of latrine ownership of households in Bali Province was 83.6%. For each of the districts, levels of latrine ownership of households are as follows Badung 95.9%, Buleleng 94%, Jembrana 93.9%, Tabanan 90.4%, Bangli 80.6%, Klungkung 71.6%, Karangasem 64.4%, and Denpasar 73.9% [39]. It should be noted that Karangasem district had the lowest level of latrine ownership where still 36.6% of households do not possess latrines, while sanitation condition in Badung district was most adequate, but still, 1.9% of households in this district did not own latrines, The level of latrine ownership of households in Denpasar (Bali's capital city) was still far from optimal (73.9%); this condition seems to be associated with the existence of several slum areas in Denpasar city where poor people, mainly immigrants, live. Lack of latrine causes the household members to have to defecate indiscriminately such as on backyards of houses, fields, paddy fields, streams, etc which may pollute the soil with STH eggs or larvae, if the individuals happen to harbor the worms.

People's access to save drinking water

For the year 2014, the overall level of people's access to safe water in Bali Province was 82.6%, which already surpassed the national target. By district, the levels of people's access to save water in order of decreasing percentages are as follows: Jembrana 95.6%, Klungkung 94.7%, Buleleng 89.8%, Tabanan 89%, Karangasem 88.2%, Bangli 88%, Badung 86.1%, Denpasar 69.5%, and Gianyar 67.8%. Levels of access to healthy water for each district were already above the national target (69.0%) except for the Gianyar district which had a little lower level [29].

Other related factors

Data of two surveys done in 1998 and 2001respectively showed 23.2% of people in rural areas never attended school and 50.4% had only completed elementary school [40,41]. A questionnaire-based survey was carried out in 2014 on pupils of an elementary school in the rural village of Samplangan, Gianyar district. showed that of 101 pupils interviewed, 97.5% said their households possessed latrines (2.5% did not have latrines); 83.2% said always, 5.8% occasionally, and 1.0% never wore footwear, respectively, when going outside their houses, 60.7% always boiled their drinking water, 10.7% occasionally, and 28.6% never; and 79.2% always washed hands before eating, 13.9% occasionally, and 6.3% never washed their hands before eating. Examination of nails of 101 pupils revealed 52.5% had clean nails and 47.5% had obviously unclean or dirty nails [42]. According to the above data, the personal hygiene and environmental sanitation of the elementary school children at Samplangan can be categorized as adequate. This particular elementary school has been included in the program of control of worm infections among elementary schoolchildren sponsored by Warmadewa University Faculty of Medicine since 2009 by means of annual health education and anthelmintic treatment.

PERSPECTIVES TOWARDS PREVENTION AND CONTROL OF STH INFECTION IN BALI

Impacts of STH infections on health

STH infections with light intensity generally cause non-specific symptoms which are transient rather than acute such as mild fever and cough due to circulating larvae of *Ascaris* and/or hookworm in lung blood circulation, indigestion, nausea or vomiting, diarrhea, abdominal discomfort, and loss of appetite [2,3,9]. In moderate to heavy STH infection, malnutrition may result in children, but even light infection can impair the growth of children who already have vulnerable nutrition status [43]. There is evidence that children chronically infected by STH tend to become more vulnerable to other infectious diseases like tuberculosis, malaria, and HIV/AIDS infection [9]. One study in Jakarta has found that children with light to moderate STH infection intensity had mild to moderate malnutrition as compared to non-infected children [44]. A study in China has found that moderate to severe STH infection intensity can cause stunting in children [45]. Some studies have shown that severe *Trichuris* infection can cause growth impairment in children [9,46,47]. Prolonged and heavy STH infection can cause lowered cognitive capacity in children and lowered ability to work in adults, and severe infection intensity of hookworm and occasionally *Trichuris* can cause iron deficiency anemia [2,9,32,43,48]. On occasions, it may cause serious complications that need urgent medical care, such as that due to erratic migration of the worm (particularly *Ascaris*) into the bile duct, appendix, Eustachian tube, nose, and intestinal obstruction or perforation [2] In regard to the high prevalence in children and adults and the various bad impacts it may cause especially to children's health, STH infection is considered as a public health problem in Indonesia in general and in Bali in particular [6,12,27,32,49].

Latest situation of STH infection in Indonesia and Bali

National control of STH infection in Indonesia was launched in 1975 under the guidance of the Ministry of Health in which priority was given to elementary school children [50]. The control program was implemented by collaborating with local health units e.g. health centers through the programs of Mother and Child Health [12], elementary schools through the program of School Health ("Usaha Kesehatan Sekolah"), government-owned and public organizations such as the Indonesian Family Planning Association (PKBI) and the Foundation of "Kusuma Buana" i.e. a non-benefit foundation focusing on controlling intestinal worm infections in Indonesia [21], By means of regular health education and mass treatment given to high-risk groups of people including elementary school children, the average national STH infection prevalence in schoolchildren was significantly reduced from 78.6% in 1987 to 8.9% in 2003 [51]. However, due to irregularity and interruption of the control program, during the last two decades since 2003 the STH prevalence in Indonesia has increased. For example, a study done in Jakarta in 2000 on different groups of people found a prevalence of 62.2% for *Ascaris*, 48.0% for *Trichuris*, and 0.72% for *hookworm* [52]. Another study carried out in 2005 in a slum area of Jakarta found 43.3% of elementary schoolchildren examined were infected with STH, of which 87.6% were infected with *Ascaris* [53]. Still another study done in 2005 on elementary schoolchildren in Jakarta found 70%-80% prevalence for *Ascaris* and 25.3%-68.4% for *Trichuris* [54]. Other data showed that in 2004 the prevalence of STH infection in school-age children had increased: 32% in Central Sulawesi. 50% in Banten 18.3% in West Java, 44% in South Sumatra, and 29.9% in West Kalimantan [12]. Similar high

prevalence rates were found in Bali. Data of surveys on different groups of people done from 1979 to 2000 showed a prevalence rate of 30.6%-99.3% for *Ascaris*, 25.8%-89.9% for *Trichuris*, and 3.3%-77.5% for *hookworm* (Table 1). Data from surveys done from 2002 to 2010 on elementary school pupils in some urban and rural villages in Badung and Gianyar district (excluded Denpasar city and Keramas and Tulikup villages where regular prevention and control program has been done) showed a prevalence of 21.9%-76.6% for *Ascaris*, 12.0%-83.5% for *Trichuris* and 0-13.0% for hookworm (Table 2). According to the above data, in Bali, the prevalence rates of STH infections in elementary school children did not differ much from the prevalence rates in different groups of people. The high prevalence of STH infections particularly in elementary schoolchildren with the possible bad impacts they cause on health, STH infections in Bali imposes a challenge to the national and local public health authorities to address the problem appropriately.

Recommended prevention and control strategies

There are three main factors that can influence the success of prevention and control programs of STH infection, namely: health education for people in the highly endemic community, mass treatment for a group of people in endemic areas, and improvement hygiene and sanitation of [10,55].

Anthelmintic treatment: Regular anthelmintic treatment is considered the most important approach to control STH infection transmission in endemic areas whSere disease control facilities are limited and funding for sanitation is insufficient. Anthelmintic treatment can be applied to the entire population is known highly endemic areas, including pre-school and school-age children, reproductive-age women, pregnant women in the second and third trimester, and special groups such as laborers of plantations and mines, regardless of their age, sex and infection status (mass drug administration). Other strategies are to give drug treatment to a targeted group of people on the basis of age, sex, and social characteristics, irrespective of their infection status (targeted treatment), and to individuals who have been diagnosed to have the most severe infection intensity, who will be at high risk of morbidity and mortality (selective treatment). School-based drug treatment gives major advantages for untreated children and the community by reducing infection transmission in the community as a whole. Selection of the treatment strategy and the frequency of treatment should be based on the analysis of available epidemiological data of the area, i.e. mainly on the level of infection prevalence, infection intensity, and reinfection rate [9,10,12]. The drugs recommended by WHO (2006) are either one of the following: (1) albendazole 400 mg or (2) levamisole 2.5 mg/kb BW or (3) mebendazole 5mg/kg BW or (4) pyrantel 10 mg kg/BW (in Indonesia often used as pyrantel plus oxantel combination). None of the four drugs is given to pregnant women in the first trimester of pregnancy, and the targeted coverage of the mass treatment is at least 75% of the population treated [12].

Health education: Health education aims to improve health and increase hygiene awareness and to change the health-related habits of the population [10]. In consideration that school-age children are mostly infected by STH species, especially *Ascaris* and *Trichuris*, it is recommended to implement health education for elementary school children. Health education should include giving information on the biological characteristics of each of the STH species, their life cycles that are related to prevention measures, and encouraging healthy habits and practices of the children such as washing hands before eating and handling food and after defecation, always keeping fingernails clean, drinking only safe/boiled water, keeping food clean, cleanliness of the indoor and outdoor environment, good wastewater drainage, wearing footwear when going outside the home, and using latrines in households, which are all important for preventing STH infection, especially among schoolchildren [10,12,24,56,57]. Health education is given to elementary school children based on the understanding that this particular group is most prone to the infection and that these children will involve their parents and other family members at their homes to start having hygienic habits and practices to prevent STH infection [10].

Sanitation improvement: Construct and use of latrines in households for human excreta disposal is most crucial to prevent STH infection [9,10]. But these particular control measures prove to face quite many handicaps. In Bali, the biggest handicap for sanitation improvement is people's poverty in the rural villages as well as in slum areas in the city which hinders people to afford even the simplest and cheapest type of latrine (e.g. the so-called "gooseneck" type of latrine). The second biggest handicap is the fact that in most of the rural villages no supply of piped water is available in households for use to flush the latrine after use. In our opinion provision of latrines and piped water supply in households is a crucial challenge faced by both Bali and the Indonesian Government to address appropriately in order to reduce or eliminate STH infection in the community. Ideally, if all households in all communities (in urban, semi-urban, and rural settings) equally possessed latrines and water supply, there would be no more soil contamination by STH infective eggs and larvae, hence no more STH infections affecting the people. However, as currently, this ideal condition is not possible due to people's inadequate economic status as well as funding limitations on the part of the government, then prevention and control of STH infection will continue to rely heavily on periodic drug treatment and public health education [58,59].

CONCLUSION

Surveys done from 1979 to 2002 in several urban and rural places of Bali have revealed that STH infection was endemic both in adult people and children, with the three most prevalent species namely *Ascaris* (30.6%-91.3%), *Trichuris* (13.8%-89.9%), and hookworm (3.3%-72.5%). Surveys carried out from 2002 to 2010 at several elementary schools in rural villages in Badung and Gianyar district have found not very much different prevalence rates, namely *Ascaris* (21.9%-76.6%), *Trichuris* (12.0%-83.5%%), and hookworm (0% to 13%). Intensity of infection of Ascaris and *Trichuris* in elementary schoolchildren was mostly light to moderate but still, a portion of them had heavy intensity. Treatment with Pyrantel proved to be effective for *Ascaris* and hookworm infection but not as effective for Triichuris infection; Albendazole was very effective for *Ascaris* and hookworm and moderately effective for *Trichuris* infection. Although the overall level of latrine ownership in households in Bali has increased in the last decade, still many of households in rural villages do not possess latrines due to economic handicaps that make many people have to defecate indiscriminately, thus causing contamination of soil with infective STH eggs that act as a source of infection. We believe that sustained and regular anthelmintic treatment and health education for schoolchildren in known endemic villages combined with the provision of latrines and safe water supply for households, despite its demanding a big investment, should be crucially undertaken by the provincial and central government in order to significantly reduce or eliminate

STH infection in the community, in particular among elementary schoolchildren.

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CONFLICT OF INTEREST

We declare that there is no conflict of interest occurring with any of the authors of this review paper.

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