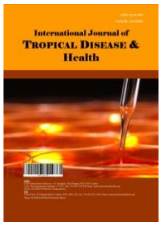

International Journal of TROPICAL DISEASE & Health

39(1): 1-10, 2019; Article no.IJTDH.52083
ISSN: 2278–1005, NLM ID: 101632866

Seasonal Pattern and Occurrence of *Schistosoma haematobium* Egg Excretion among Pregnant Women in Munyenge, South West Region, Cameroon

Godlove Bunda Wepnje[1*], Judith Kuoh Anchang-Kimbi[1], Leopold Gustave Lehman[2] and Helen Kuokuo Kimbi[1,3]

[1]Department of Zoology and Animal Physiology, Faculty of Science, University of Buea, P.O.Box 63, Buea, Cameroon.
[2]Department of Animal Biology, Faculty of Science, University of Douala, P.O.Box 24157, Douala, Cameroon.
[3]Department of Medical Laboratory Sciences, Faculty of Health Sciences, The University of Bamenda, P.O. Box 39, Bambili, Cameroon.

Authors' contributions

This work was carried out in collaboration among all authors. Author GBW did conception and design of study, data collection, analysis, interpretation and wrote the manuscript. Author JKAK supervised and critically reading of manuscript for important and intellectual content. Authors LGL and HKK supervised and revision of manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJTDH/2019/v39i130196
Editor(s):
(1) Dr. Thomas I. Nathaniel, Department of Biomedical Sciences, School of Medicine -Greenville, University of South Carolina, Greenville, USA.
Reviewers:
(1) K. Kiki Barro Pulchérie Christiane Maie, Félix Houphouët-Boigny University, Côte d'Ivoire.
(2) Tawanda Jonathan Chisango, Chinhoyi University of Technology, Zimbabwe.
Complete Peer review History: http://www.sdiarticle4.com/review-history/52083

Original Research Article

Received 10 August 2019
Accepted 16 October 2019
Published 31 October 2019

ABSTRACT

Aim: The aim of this study was to describe temperature, precipitation pattern and the occurrence of maternal urogenital schistosomiasis (UGS) in Munyenge in 2017.
Study Design: It was a twelve-month cross-sectional study.
Study Site and Duration: The study was carried out in Munyenge from January to December 2017.

**Corresponding author: Email: wepnje.godlove@ubuea.cm;*

Materials and Methods: Volunteer pregnant women attending antenatal care clinic were enrolled consecutively on a monthly basis from January to December 2017. A semi-structured questionnaire was used to obtain information on socio-demographic data and water contact behaviour. Urine samples were analysed for presence of microhaematuria and/or *Schistosoma haematobium* ova using filtration method. Monthly land surface temperature (LST) and precipitation were sourced from MODIS and CHIRPS satellite data respectively. Statistical analyses performed were analysis of variance, student t- test and correlation analysis.

Results: The mean annual temperature was 27.18 ± 0.74°C. Monthly temperatures were fairly constant (range: 26.12 to 28.82°C). Precipitation varied greatly (range: 0.26 - 12.75 mm) with a mean of 6.58 ± 4.5mm. A marginal negative correlation (r = -0.586; *P* = .04) was observed between stream usage and precipitation where stream usage reduced with increase in precipitation. Generally, there was high dependence on the stream as source of water (60.9 - 90.6%) in the study area. Dependency on the stream was associated (r = 0.603; *P* = .03) with domestic and bathing activities. The annual prevalence of maternal UGS was 24.1% (77/320) with a high occurrence during the rainy season (16.6%; 53/320) than the dry season (7.5%; 24/320) but the difference was not significant (χ^2 = 2.26; *P* = .13). There was no significant difference between months.

Conclusion: Our findings show no seasonal variation in the occurrence of maternal UGS in Munyenge. Transmission of infection may be perennial.

Keywords: Schistosoma haematobium; pregnancy; LST; precipitation; stream contact behaviour; Munyenge.

ABBREVIATIONS

ANC : Antenatal Care
UGS : Urogenital Schistosomiasis
LST : Land Surface Temperature
MODIS : Moderate Resolution Imaging Spectroradiometer
CHIRPS : Climate Hazards Infrared Precipitation with Station

1. INTRODUCTION

Schistosomiasis is considered as one of the Neglected Tropical Diseases (NTDs) and its burden is disproportionately concentrated in Africa [1–3] where people living in areas with limited access to safe water, sufficient sanitation and hygiene [4,5] and adequate levels of appropriate health education [6] are highly at risk to the disease. Human infection tends to vary with host immunity, water contact patterns and geographical location defined by the specific range of snail intermediate host habitat [5,7]. Urogenital schistosomiasis is transmitted by *Schistosoma haematobium* that develops into the human-infective stage within *Bulinus* snails that act as the intermediate host [8].

The infectious form of the parasite, the cercariae infect humans penetrating their skin when they come into contact with contaminated freshwater [1]. The microscopic worms migrate through the body until they develop into sexually mature adults and lay eggs in about 25–30 days of infection [9]. Some of the eggs are passed out of the body in urine to continue the parasite life cycle and the rest remain in the body causing pathology associated to infection.

Climatic factors are considered important in the spatial and temporal distribution of vector borne diseases as they determine vector distribution and influence annual occurrence of the disease and long-term trends [10]. The climatic factors frequently considered are temperature and precipitation which are fundamental drivers of schistosomiasis transmission. Both factors show a positive correlation with prevalence of infection [11]. Rainfall is largely responsible for creating the conditions that allow sufficient surface water accumulating in freshwater bodies and providing abundant snail breeding sites. The temperature of water bodies governs the development rate of the parasite within snails and the infectivity of cercaria [12–14]. Satellite temperature and precipitation products are suitable in providing useful information to understand and model the relationship between meteorological conditions and *Schistosoma* prevalence [9]. In recent years, a number of studies have indicated that *S. haematobium* infection exhibits seasonal variation [15–17] and that infection may vary between countries and even between regions in the same country. In some areas, the prevalence of *S. haematobium* is higher in the dry season [17–19], while in other areas, it is higher during the rainy season [20,21]. Also, perennial transmission has been reported in some areas [21,22]. Schistosomiasis is not only influenced by climatic factors but human behavior and socio-economic factors play a key role in the schistosomiasis transmission process [23,24]. Through various water contacts, the human being ensures the successful transmission of the parasite [6,25-28]. Climatic factors as well influence water contact patterns [29,30]. Extensive epidemiological surveys on UGS has been carried out in Munyenge [31,32]. Ebai et al. [31] and Ndassi et al. [32] carried out two independent surveys, one in the rainy season and other in the dry season respectively but none assessed the occurrence of this infection across the different seasons. Thus, this study described the seasonal (land surface temperature and precipitation) and annual maternal UGS pattern in Munyenge, South West Region, Cameroon.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Munyenge, a rural area located in the Mount Cameroon area, South West Region, Cameroon. Munyenge lies between longitudes 9.363 E and 9.292 E and latitudes 4.329 N and 4.401 N with an altitude ranging from 87 to 168m above sea level. The characteristics of the study area was described elsewhere [33]. The study sites included the three health facilities (Government Integrated Health Centre, Trans African Health services and Banga Annex Health Centre) that provide healthcare, antenatal care and delivery services for the local population of Munyenge. The Mount Cameroon area has an equatorial climate with two distinct seasons: a rainy season which lasts from March to October followed by a short dry season of four months (November to February) [34]. This area is known for its higher rate of UGS prevalence when compared with Ikata and Bafia neighbouring communities [31,35]. Transmission of *S. haematobium* in the area is favoured by the presence of the snail intermediate host, frequent water contact with cercaria-infested streams and inadequate supply of piped water [33,36,37]. Nonetheless, recent reports show scale-up of communal piped-water sources between 2014 and 2017 [33] and these may account for the reduction of UGS in this endemic focus [31,33].

2.2 Population Size Determination

Using the prevalence of 46.8% UGS reported in pregnant women in Munyenge in the Mount Cameroon region by Anchang-Kimbi et al [37], the sample size was determined using the formula $n = Z^2pq/d^2$ [38] where n = the sample size required, Z = 1.96: confidence level test statistic at the desired level of significance, p = 46.8%: Proportion of US prevalence, q = 1 – p: Proportion of schistosome negative individuals and d = acceptable error willing to be committed. The minimum sample size was estimated as n = 382. However, due to logistics, we had a sample size of 320 pregnant women which is well above 80% of the expected sample size calculated.

2.3 Sample Collection and Laboratory Analyses

A twelve-month cross-sectional survey of UGS prevalence was carried out between January to December 2017 during which pregnant women reporting for antenatal care clinic at any of the three-primary healthcare centres (Government Integrated Health Centre, Banga-Annex Health Centre and Trans African Health Services) were enrolled consecutively. Written informed consent was obtained from the participants before enrolment. A structured questionnaire was administered to consented expectant women to obtain socio-demographic data (age, marital status, educational level and occupation), gravidity status and potential factors related to schistosomiasis (stream usage, activities carried out in the stream and stream frequency).

Collection and analysis of urine samples were performed following standard procedures [39]. Briefly, all participants received pre-labeled transparent bottles for urine collection between 10 am and 2 pm. The urine was screened for microhaematuria using urine reagent strip (Mission®, ACON Laboratories, Inc, USA). The filtration technique was used to determine urinary schistosome egg excretion as described elsewhere [37]. Briefly, 10 ml of urine was filtered using membrane filters (Sterlitech Polycarbonate (PCTE) membrane filters, USA) which retained the schistosome eggs. The membrane filter was then placed on a microscope slide and examined under light microscopy (Olympus NYUSA). The number of eggs counted was reported per 10 ml of urine. A pregnant woman was diagnosed for *S. haematobium* infection when she was positive by microscopic examination and/or urine reagent strip.

2.4 Data Source for Precipitation and Land Surface Temperature

Land surface temperature and precipitation estimates were obtained from standard satellite products. The land surface temperature (LST) estimates were obtained from the MOD11 product [40], derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on board the polar-orbiting satellites Terra and Aqua which pass over a given region once a day. Precipitation estimates were obtained from the satellite rainfall product Climate Hazards Infrared Precipitation with Station Data (CHIRPS) [41].

2.5 Data Management and Analysis

Data were analysed using SPSS version 22.0 (SPSS, Inc., Chicago, IL, USA) and Microsoft Excel 2010 (Microsoft Corp., USA). The monthly prevalence of infection, LST, precipitation, stream usage, frequency of contact with stream as well as type of stream activity were calculated and used to establish monthly and seasonal variations. Group means were compared using analysis of variance (ANOVA) and student t- test and correlation analysis to ascertain associations between continuous variables. Graphs were used to show trend of infection with the factors stated above. *P* value < .05 was considered significant.

3. RESULTS

3.1 Temperature and Precipitation Pattern in the Study Area

The mean annual land surface temperature for 2017 was 27.18 ± 0.74°C and varied between 26.12 to 28.82°C. Monthly mean temperatures showed a fairly constant trend (Fig. 1). There was no statistically significant difference (t = -0.87; *P* = .40) in mean temperatures between the rainy (27.05 ± 05) and dry (27.45 ± 1.2) seasons. There was a high degree of intra-annual variability (range: 0.26 - 12.75 mm) in precipitation with a mean of 6.58 ± 4.5 mm. A significantly higher (t = 4.47; *P* < .001) precipitation was recorded during the rainy (9.04 ± 2.8) than the dry (1.6 ± 2.5) season. The intensity of rains was classified as follows; early rains (March –May), heavy rains (June – August), late rains (September – November) and little or no rains (December to February) with mean precipitation levels of 6.17 ± 0.42mm, 11.9 ± 0.77 mm, 7.9 ± 2.7 mm and 0.34 ± 0.68 mm respectively. The difference was statistically significant (F = 36.34; P <.001).

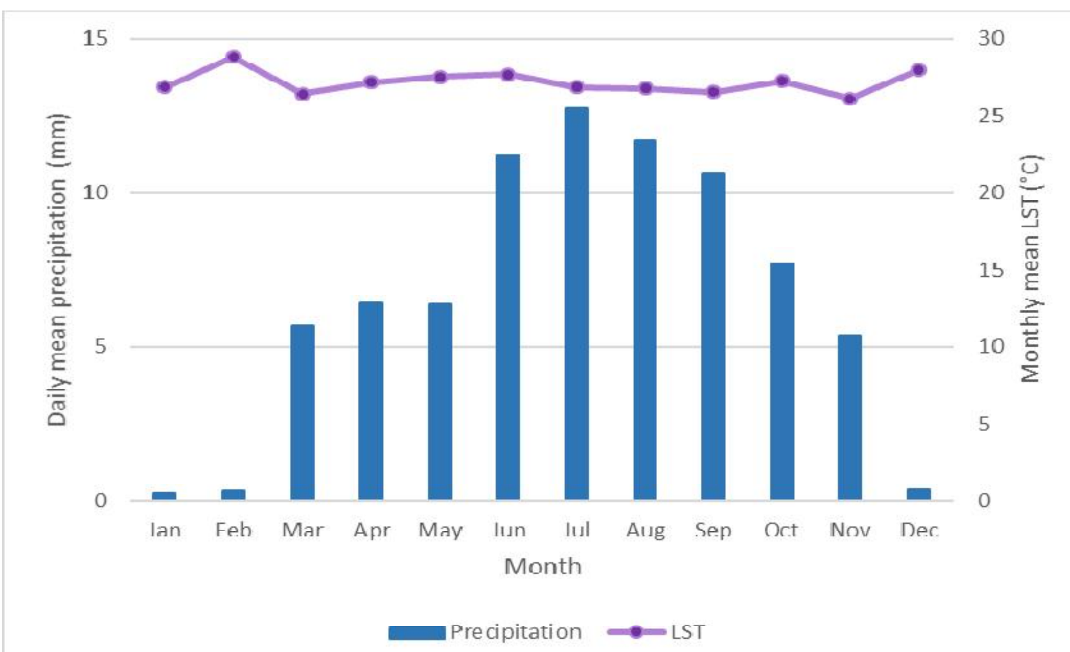

Fig. 1. Annual precipitation and LST distribution in Munyenge in 2017

3.2 Characteristics of Study Participants

A total of 320 women were enrolled within a one-year study period. The mean age of the women was 25.6 ± 5.6 (range: 15–42) with more women in the older age group (>25 years) (47.2%; n= 151) and multi gravidae (45%; n = 144). The proportion of married women were about twice higher (73.9%; n = 232) than that of singles. With regards to occupation, a greater number of women were housewives (32.8%; n = 105) while 21.9% (70), 20.6% (66) and 24.7% (79) being student, farmer and doing business respectively. A majority of the women (57.5%; n = 184) had obtained at least a secondary level of education.

3.3 Occurrence of *S. haematobium* Infection

The overall prevalence of maternal UGS was 24.1% (77/320). Micro haematuria was reported in 15.6% (50/320) of women. Fig. 2 presents the occurrence of *S. haematobium* egg excretion among pregnant women on a monthly scale from January to December 2017. Infection level varied between 8.3% (July 2017) and 38.1% (December 2017). It is worth noting that no month over the one-year period passed without an *S. haematobium*- infected case. *S. haematobium* infection exhibits varying peaks with higher prevalence within particular months. Peak egg excretion occurred in May (37.5%; 9/24), August (34.8%; 8/23) and December (38.1%; 8/21). However, there was no significant difference in prevalence between months (χ^2= 15.69; *P* = .15). A higher prevalence of egg excretion was recorded in the rainy season (16.6 %; 53/320) than in the dry season (7.5%; 24/330), although the difference was not statistically significant (χ^2 = 2.26; *P* = .13).

3.4 Stream Contact Behaviour in the Study Area

Generally, there was high dependence on the stream as source of water (60.9 - 90.6%) in the study area (Fig. 3a). Visit to the stream was significantly (r = 0.603; *P*= .03) associated with stream activities such as domestic chores and bathing (Fig. 3b). A marginal significant negative correlation (r = -0.586; *P*= .04) was observed between stream usage and precipitation where stream usage reduced with increase precipitation. It is worth noting that, women who used piped water also used the stream (r = 0.613; *P* = .03).

4. DISCUSSION

Basic information regarding annual variation of maternal urogenital schistosomiasis can greatly enhance control efforts in endemic communities. This baseline study describes annual seasonal pattern of Munyenge as well as reports on the occurrence of *S. haematobium* egg excretion in the study area during the period from January to December 2017.

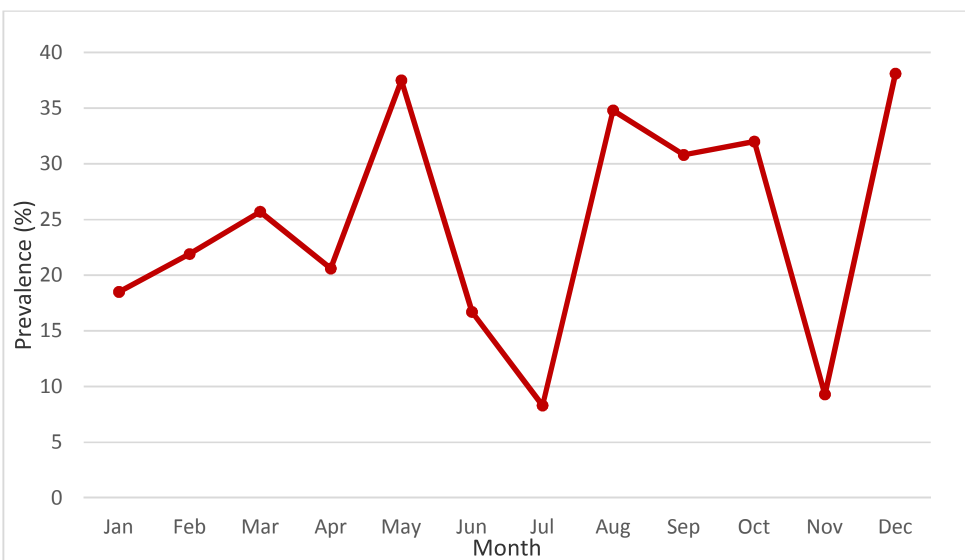

Fig. 2. Annual occurrence of UGS among pregnant women in Munyenge in 2017

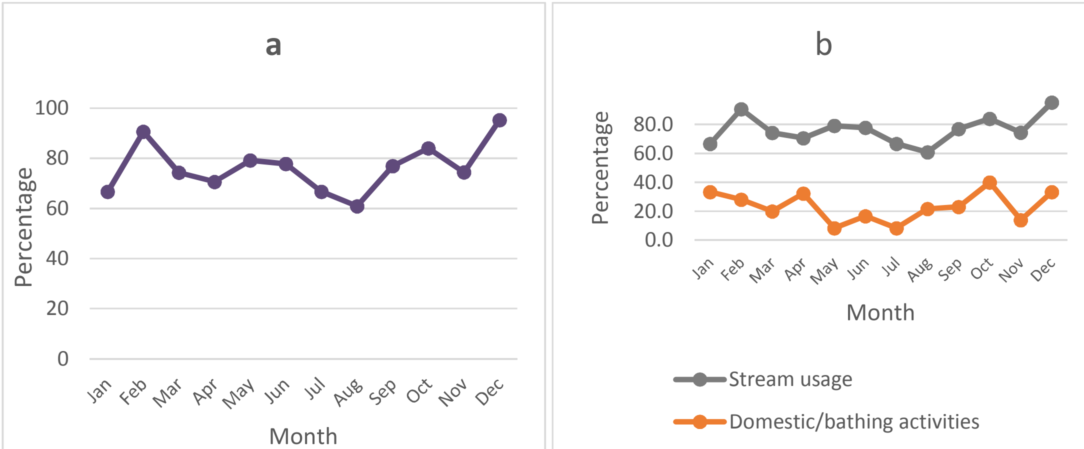

Fig. 3. a: Monthly stream usage b: Monthly stream usage and stream activity

Temperature and precipitation are fundamental drivers of schistosomiasis transmission as they determine snail distribution and influence annual occurrence of the disease [10,11]. Experimental studies have showed that the suitable temperature range for cercaria development in the laboratory is between 15°C to 35°C, with an optimum temperature of 25°C for development within the mollusc [13,42]. The temperature pattern observed in the present study was within range of that which enhances cercarial incubation, shedding and infectivity. Similar to findings of Stirewalt and Fregeau [43], the monthly mean temperatures (Range: 26.12 to 28.82°C) is optimum for cercarial infectivity. Tay et al. [44] suggested that temperature enhanced cercaria shedding to maintain infection within the study community. Longer rainfall period in the study largely sustains conditions that allow sufficient surface water accumulating in freshwater bodies and providing abundant snail breeding sites [45]. However, variations in rainfall tend to induce cyclic fluctuations in the infection rate and intensity of infection in the intermediate host. Rainfall may affect the level, rate of flow and the chemistry of a given body of water. Snails will turn to flourish at the start of the rainy season and may reduce as a result in the flooding of the snail habitat thereby dislodging them and leading to a fall in number [45].

In Munyenge stream water sources are often associated with high occurrence of snail intermediate host species (*Bulinus* sp) for urinary schistosome parasite [33]. About one in four women was positive for worm during pregnancy suggesting that the disease is an important public health concern in Munyenge. It is well-known that the transmission of schistosomiasis is common among rural African women who obtain water for domestic and other uses from springs and streams [46–49]. The high dependency on stream as water source in this setting is partly influenced by inadequate access to pipe-borne water despite scale up of communal piped water sources [33,37]. Climate exerts indirect effect on the appearance and spread of infectious diseases by altering human behaviour and hence exposure to infection and disease [50]. With regards to the present study, an inverse relationship was observed between stream usage and precipitation where stream usage reduces with increase rainfall. This finding corroborates those of Codjoe and Larbi [29] in Ghana and Ugbomoiko [51] in Nigeria which showed the reduction of water contact behaviour (bathing, swimming and fishing activities) with increase rainfall. In Munyenge, women use the stream purposely for domestic and bathing activities. Both activities cause the most exposure to cercaria-infested water since it involves the immersion of large body parts for long periods [37,52,53].

Our findings demonstrate high occurrence of *S. haematobium* egg excretion in the rainy season than the dry season. This corroborates findings of Houmsou [21] in Nigeria, who reported no monthly or seasonal difference in the prevalence of infection. On the contrary, well- marked seasonal variation in *Schistosoma* infection was reported by several authors [16,17,54–56]. The absence of seasonal difference in the occurrence in infection may suggest perennial transmission of infection noting high dependency of the population on stream water source. Also, the short-term (one-year lag time) investigation period may have allowed some infected cases go undetected. The incubation period of schistosomiasis is at least six weeks [57]. This may result in egg excretion after a considerable period of time had elapsed from the time of infection. Our study did find this as a cofounding factor as to when the individual was infected and when enrolled in the study. There are also reports of live ova excretion many years after exposure, indicating worm longevity and persistent ability to lay eggs [3].

5. CONCLUSION

The seasonal pattern observed in Munyenge will enhance cercarial incubation, shedding and infectivity. There was high dependency on stream for bathing and domestic activities that will increase infectivity of population. There is no seasonal difference in the occurrence of *S. haematobium* egg excretion suggesting perennial transmission.

CONSENT AND ETHICAL APPROVAL

The study protocol was approved by the Ethical and Scientific Committee of the Institutional Review Board, Faculty of Health Sciences, University of Buea (No2017/0481/UB/FHS/IRB). Approvals were also obtained from the South West Regional Delegation of Public Health, Buea and the District Medical Officer for Muyuka Subdivision. Written informed consent was obtained from the women. Participation was voluntary, and participants were permitted to quit at any time.

ACKNOWLEDGEMENTS

The authors are grateful to all the pregnant women who gave their consent to participate in the study as well as all health facilities used. We are heartily thankful to Dr. Jodie Dionne-Odom and Miss. Renata Hocking of the University of Alabama at Birmingham for the provision of kits for the filtration method as well as Dr. Julius Yuh Anchang who provided climate data from satellite.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. WHO Prevention and control of schistosemiasis and soil-transmitted helminthiasis: Report of a WHO expert committee. WHO Technical Report Series. 2002;912:1–57.
2. Van der Werf MJ, de Vlas SJ, Brooker S, Looman CW, Nagelkerke NJ, Habbema JD, et al. Quantification of clinical morbidity associated with schistosome infection in sub-Saharan Africa. Acta Tropica. 2003; 86:125-39.
3. King CH, Dangerfield-Cha M. The unacknowledged impact of chronic schistosomiasis. Chronic Illn. 2008;4:65-79.
4. King CH, Dickman K, Tisch DJ. Reassessment of the cost of chronic helminthic infection: A meta-analysis of disability-related outcomes in endemic schistosomiasis. Lancet. 2005;365:1561–9.
5. Colley DG, Bustinduy AL, Secor WE, King CH. Human schistosomiasis. Lancet. 2014; 383:2253–64.
6. Kloos H. Human behavior, health education and schistosomiasis control: A review. Society of Science and Medicine. 1995;40:1497–511.
7. Angelo T, Buza J, Kinung'hi SM, Kariuki HC, Mwanga JR, Munisi DZ et al. Geographical and behavioral risks associated with *Schistosoma haematobium* infection in an area of complex transmission. Parasites & Vectors. 2018;11:481.
DOI: 10.1186/s13071-018-3064-5
8. Roberts L, Janovy J. Foundations of parasitology. 5th ed., Wm. C. Brown Publishers, Dubuque, Iowa; 1996.
9. Xue Z, Gebremichael M, Ahmad R, Weldu ML, Bagtzoglou AC. Impact of temperature and precipitation on propagation of intestinal schistosomiasis in an irrigated region in Ethiopia: Suitability of satellite datasets. Tropical Medicine and International Health. 2011;16(9):1104–1111.
10. Parham PE, Michael E. Modeling the effects of weather and climate change on malaria transmission. Environ Health Perspect. 2010;118:620–6.
11. Ajakaye OG, Olusi TA, Oniya MO. Environmental factors and the risk of urinary schistosomiasis in Ile Oluji/Oke Igbo local government area of Ondo state. Parasite Epidemiology and control. 2016; 1:98-104.
12. Appleton CC. Review of literature on abiotic factors influencing the distribution and life cycle of bilharziasis intermediate

host snail. Malacology Review. 1978;11:1-25.
13. Malone JB. Biology-based mapping of vector-borne parasites by geographic information systems and remote sensing. Parassitologia. 2005;47:27–50.
14. Thieltges D, Jensen K, Poulin R. The role of Biotic factors in the transmission of free-living endohelminth stages. Parasitology. 2008;135:407-426.
15. Augusto G, Magnussen P, Kristensen T, Appleton C, Vennervald B. The influence of transmission season on parasitological cure rates and intensity of infection after praziquantel treatment of *Schistosoma haematobium*-infected school children in Mozambique. Parasitology. 2009;136(13): 17711779.
16. Gbalégba N, Silué K, Ba O, Ba H, Tian-Bi NTY, Yapi GY, et al. Prevalence and seasonal transmission of *Schistosoma haematobium* infection among school-aged children in Kaedi Town, Southern Mauritania. Parasites Vectors 2017;10(1): 353.
DOI: org/10.1186/s13071-017-2284-4
17. Christensen EE, Taylor M, Zulu SG, Lillebo K, Gundersen SG, Holmen, S, et al. Seasonal variations in *Schistosoma haematobium* egg excretion in school-age girls in rural KwaZulu-Natal Province, South Africa, South Africa Medicine Journal. 2018;108(4):352-355.
18. Nwabueze AA, Opara KN. Urinary schistosomiasis among school children in riverine communities of Delta State, Nigeria: Impact of road and bridge construction. Journal of Medical Sciences. 2007;7(4):572–578.
19. Opara KN, Udoidung NI, Ukpong IG. Genitourinary schistosomiasis among primary school children in a rural community within the Cross-river basin, Nigeria. Journal of Helminthology. 2007; 81(4):393–397.
20. Sarkinfada F, Oyebanji AA, Sadiq IA, Ilyasu Z. Urinary schistosomiasis in the Danjarima community in Kano, Nigeria. The Journal of Infection in Developing Countries. 2009;3(6):452–457.
21. Houmsou RS. Profile of a one-year epidemiological study of urinary schistosomiasis in two Local Government Areas (LGAs) of Benue State, Nigeria. Journal of Biomedical Sciences. 2012; 1(2).
DOI: 10.3823/1006
22. Kahama AI, Vennervald BJ, Kombe Y, Kihara RW, Ndzovu M, Mungai P, et al. Parameters associated with Schistosoma haematobium infection before and after chemotherapy in school children from two villages in the Coast province of Kenya. Trop Med Int Health. 1999;4:335–40.
23. Allotey P, Reidpath D, Pokhrel S. Social sciences research in neglected trop-ical diseases 1: The ongoing neglect in the neglected tropical diseases. Health Res. Policy Syst. 2010;8:32.
24. Utzinger J, N'Goran EK, Caffrey CR, Keiser J. From innovation to application: Social-ecological context, diagnostics, drugs and integrated control of schistosomiasis. Acta Tropica. 2011; 120(1):121–137.
25. Chandiwana SK. Community water contact patterns and the transmission of *Schistosoma haematobium* in the Highveld region of Zimbabwe. Social Science and Medicine. 1987;25:495–505.
26. Takougang I, Meli J, Fotso S, Angwafo F, Kamajeu R, Ndumbe PM. Some social determinants of urinary schistosomiasis in northern Cameroon: Implications for schistosomiasis control. African Journal of Health Sciences. 2004;11(3– 4):111–120.
27. Scott JI, Daikhate M, Vereeeken K, Fall A, Drop M, Ly A, et al. Human water contact Patterns in *S. mansoniepidemic* foci in Northern Senegal. Tropical Medicine and International Health. 2003;8(2):100-108.
28. Gazzinelli A, Velasquez-Melendez G, Crawford SB, LoVerde PT, Correa-Oliveira R, Kloos H. Socioeconomic determinants of schistosomiasis in a poor rural area in Brazil. Acta Trop. 2006;99:260–271.
29. Codjoea SNA, Larbi RT. Climate change/variability and schistosomiasis transmission in Ga district. Ghana. Climate and Development; 2015.
DOI: 10.1080/17565529.2014.998603
30. Traore I, Karthe D, Sie A, Coulibaly V, Kappas M. Influence of air temperature on children water contacts with respect to schistosomiasis transmission risk in the Sourou Valley, Burkina Faso. Stoch Environ Res Risk Assess. 2016;30:2097–2107.
31. Ebai CB, Kimbi HK, Sumbele IUN, Jude EY, Lehman GL. Prevalence and risk factors of urinary Schistosomiasis in the Ikata-Likoko Area of Southwest Cameroon. International Journal of Tropical Disease and Health; 2016.

DOI: 10.9734/IJTDH/2016/26669
32. Ndassi VD, Anchang-Kimbi JK, Sumbele IUN, Wepnje GB, Kimbi HK. Prevalence and risk factors associated with *S. haematobium* egg excretion during the dry season, six months following mass distribution of Praziquantel (PZQ) in 2017 in the Bafia Health Area, South West Region Cameroon: A cross-sectional study. Journal of Parasitology Research; 2019.
Available:https://doi.org/10.1155/2019/4397263
33. Wepnje GB, Anchang-Kimbi JK, Ndassi VD, Lehman LG, Kimbi HK. *Schistosoma haematobium* infection status and its associated risk factors among pregnant women in Munyenge, South West Region, Cameroon following scale-up of communal piped water sources from 2014 to 2017: A cross-sectional study. BMC Public Health; 2019.
DOI: 10 1186/s 12 889-019
34. Basco LK, Ngane VF, Ndounga M, Same-Ekobo A, Youmba JC, Abodo RTO, et al. Molecular epidemiology of malaria in Cameroon. XXI. Baseline therapeutic efficacy of chloroquine, amodiaquine, and sulfadoxine-pyrimethamine monotherapies in children before national drug policy change. Am J Trop Med Hyg. 2006;75: 388–95.
35. Ntonifor HN, Green AE, Bopda MOS, Tabot JT. Epidemiology of urinary schistosomiasis and soil transmitted helminthiasis in a recently established focus behind Mount Cameroon. International Journal of Current Microbiology and Applied Sciences. 2015;4(3):1056-1066.
36. Ntonifor HN, Mbunkur GN, Ndaleh NW. Epidemiological survey of urinary schistosomiasis in some primary schools in a new focus behind mount Cameroon, South West Region, Cameroon. East African Medicine Journal. 2012;89(3):82-88.
37. Anchang-Kimbi J, Dillys M, Taiwe GS, Eric A. Coinfection with *Schistosoma haematobium* and *Plasmodium falciparum* and Anaemia Severity among Pregnant Women in Munyenge, Mount Cameroon Area: A cross-sectional study. Journal of Parasitology Research; 2017.
DOI: 10.1155/2017/6173465
38. Bryan FJ. The design and analysis of research studies, university of Otago, Dunedin, New Zealand. Cambridge, UK: Cambridge University Press; 1992.
39. Cheesbrough M. District laboratory practice in tropical countries, Cambridge University Press, Cambridge, UK; 2006.
40. Wan Z, Hook S, Hulley G. MOD11A1 MODIS/Terra Land Surface Temperature/ Emissivity Daily L3 global 1km SIN grid V006. 2015, distributed by Nasa EOSDIS LP DAAC.
DOI: ORG/10.5067/MODIS/MOD11A1.006
41. Funk C, Peterson P, Landsfeld M, Pedreros D, Verdin J, Shukla S, et al. The climate hazards infrared precipitation with stations—A new environmental record for monitoring extremes. Sci. Data. 2015; 2:150066.
42. Anderson R, May R. Prevalence of schistosome infections within molluscan populations: Observed patterns and theoretical predictions, Parasitology. 1979; 79;63-94.
43. Stirewalt MA, Fregeau WA, Exp. Parasitol. 1968;22:73.
44. Tay SCK, Amekudzi LK, Tagoe G. Comparative study of the impact of climate variability on prevalence of urinary schistosomiasis: Cases at Sunyani Regional Hospital and among School Children in Atronie, Sunyani. Journal of Environmental Science and Engineering. 2011;5(11):1474-1482.
45. Ivoke N, Ivoke ON, Nwani CD, Ekeh FN, Asogwa CN, et al. Prevalence and transmission dynamics of *Schistosoma haematobium* infection in a rural community of southwestern Ebonyi State, Nigeria. Tropical Biomedicine. 2014;31(1): 77–88.
46. Onwuliri COE, Anosike JC, Oguoma C, Onwuliri VA, Nwoke BEB, Dozie INS, et al. The impact of cultural limitations, local beliefs and practices on emerging parasitic diseases in tropical Africa. International Journal of Natural and Applied Sciences. 2005;1(2):153-164.
47. Obi CL, Momba MNB, Samie A, Igumbor JO, Green E, Musie E. Microbiological, physico-chemical and management parameters impinging on the efficiency of small water treatment plants in the Limpopo and Mpumalanga Provinces of South Africa W ater SA. 2007;33:229-237.
48. Downs JA, Mguta C, Kaatano GM, Mitchell KB, Bang H, Simplice H, et al. Urogenital schistosomiasis in women of reproductive

age in Tanzania's Lake Victoria region. Am J Trop Med Hyg. 2011;84:364–9.
49. Zida A, Briegel J, Kabré I, Sawadogo MP, Sangaré I, Bamba S, et al. Epidemiological and clinical aspects of urogenital schistosomiasis in women, in Burkina Faso, West Africa. Infectious Diseases of Poverty. 2016;5:81.
50. WHO. Global Survey of Early Warning Systems; 2004. Available:https://www.unisdr.org/2006/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf [assessed 10.04.2019].
51. Ugbomoiko US. Seasonal patterns in water contact and transmission of *Schistosoma haematobium* infection in Ikpeshi, Edo State, Nigeria. Niger. J. Pure Applied Sci. 2004;19:1560-1569.
52. Ekwunife CA. Socio-economic and water contact studies in *Schistosoma haematobium* infested area of Anambra State, Nigeria. Anim Res Int. 2004;1:200–2.
53. Omonijo A, Asaolu S, Ofoezie I. Schistosomiasis transmission and water contact pattern in river Ureje in Ado-ekiti local government area, Ekiti State. Res J Parasitol. 2013;8:26–36.
54. Pitchford RJ, Visser PS. Some further observations on *schistosome* transmission in the Eastern Transvaal. Bull World Health Organ 1965;32(1):83-104.
55. Wilkins HA, Scott A. Variation and stability in *Schistosoma haematobium* egg counts: A four-year study of Gambian children. Trans R Soc Trop Med Hyg 1978;72(4): 397-404.
56. Ciddio M, Mari L, Gatto M, Rinaldo A, Casagrandi R. The temporal patterns of disease severity and prevalence in schistosomiasis. Chaos 2015;25(3): 036405. DOI: Org/10.1063%2f1.4908202
57. World Health Organisation. The control of Schistosomiasis (Second Report of WHO Committee. Technical Report Series 830). Geneva: WHO; 2008.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/52083