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Sex-Biased Prevalence of Intestinal Parasitic Infections and Gender Inequality in Rural Nepal

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ABSTRACT

Objectives: Intestinal parasitic infections (IPIs) are related to poverty and socioeconomic disparities. In rural Nepal, IPIs are highly endemic and gender inequality is still deeply rooted. This study provides a novel epidemiological assessment of IPIs in Nepal, juxtaposing spatial, age and sex stratification of prevalence.

Methods: A PRISMA and PICO-based systematic review of peer-reviewed and grey literature provided IPI prevalence data for the Nepalese population. Demographic and environmental variables were considered to investigate differences related to dwelling area and sex. Variations among prevalence rates were calculated with 95% CI and significance level for odds ratio evaluated with chi-square test.

Results: The IPI prevalence rate for the Nepalese general population was 37.6%. Moreover, IPI prevalence (52.3%) was significantly higher in rural areas than in urban areas (32.4%), and school-age girls (55.2%) were more infected than boys (48.6%).

Conclusions: The IPI infection rate appeared to be enhanced among young women living in rural Nepal, where they experienced low school attendance and heavy enrolment in agricultural work, as result of gender discrimination. Plausibly, these dynamics affect both girls' environmental exposure and fruition of periodic school-based preventive chemotherapy, thus increasing the chances of IPI infection.

Introduction

Intestinal parasitic infections (IPIs) are broadly ascribed to two groups of pathogens: protozoa and helminths. At a worldwide level, IPIs are considered one of the most relevant neglected public health issues. Such infections are endemic in developing countries with tropical and subtropical climates, especially in rural areas with poor sanitation. Approximately 3.5 billion people in developing countries are infected by at least one intestinal parasite species, with children being especially affected (Okyay et al., 2004). With childhood being critical for both physical and cognitive development, IPI-associated burden of disease in this period of life is of particular relevance: chronic infection can lead to nutritional deficiency, anaemia, growth retardation, and impaired learning ability (Hall et al., 2008). High prevalence of IPIs is associated with several socioeconomic and environmental factors: poverty, low literacy rate, poor hygiene, unsafe water sources, suitable temperature and humidity (Pullan et al., 2014, Pullan and Brooker, 2012). Among these, gender inequalities commonly worsen the gap between women and men in terms of health, life expectancy and quality of life (United Nations Women. Progress of Women in Nepal (1995-2015) 2015).

The core principle of the UN Sustainable Development Goals (SDGs) is that of *leaving no one behind*, thus addressing poverty and overlooked issues linked to ethnicity, language, caste, disability, age and gender (National Planning Commission 2015). In order to accomplish the 2030 agenda in Nepal, gender inequalities and child labour list among the biggest challenges that the country ur-

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gently needs to address (Gender Equality and Social Inclusion 2017, International Labour Organization 2014).

According to the 2011 census, Nepal has a population of over 26 million people, with an average growth rate of the population of 1.35 per year (Central Bureau of Statistics 2012). Most people live in the southern plain region of Terai and the central hill region, with roughly 83% of citizens residing in rural villages and few urban areas with high population density (Central Bureau of Statistics 2014). About one-fourth of the Nepalese population lives below the poverty line. However, the country recently ranked as the third fastest-growing economy in the world, particularly due to reconstruction efforts after the 2015 earthquakes, regularisation of commercial trade with neighbouring India, and resolution of the 10-year armed civil conflict (World Bank Group 2017). These and other factors have considerably improved the living situation of the general population, but disparities have also substantially increased. Nepal ranks 144 out of 188 countries in the Human Development Index (HDI), as well as in the Gender Inequality Index (GII) (United Nations Development Programme 2016). These indicators slowly seem to be improving, but implementation of specific policies is needed to address issues such as the gender gap and urban/rural disparities (Central Bureau of Statistics 2014).

Although the country is experiencing an important process of modernisation, gender gaps are historically deep-rooted and are still very pronounced (Bennett, 2008). Women are traditionally viewed as symbols of power and purity and are respected for their virtues (e.g. cleanliness and virginity). Women often have to fulfil traditional roles in the household and economically depend on their spouse or father, if unmarried (Muldoon et al., 2017).

While women are increasingly participating in the labour market, large gender disparities exist in terms of occupational status, wages, and social position in favour of male workers (International Labour Organization 2017). A similar pattern has been observed for literacy rates, health status, and access to health services (Central Bureau of Statistics 2014). The increased rate of men's out-migration (both domestic and international) has resulted in marked differences in employment opportunities, with rural areas counting more women in the labour force than men, and female workers being more likely to be employed in agriculture than men – a phenomenon known as feminisation of agriculture (Allendorf, 2007, Gartaula et al., 2010). Despite the potentially positive implications of women's leadership in the management of farming and household production for empowerment and gender equity (Mishra and Sam, 2016), this increased workload has also been linked to a number of negative consequences, such as food insecurity and higher anxiety levels (Tamang et al., 2015).

Gender inequality does not only concern adult women, as disparity starts early in childhood.

Gender discrimination among Nepalese children is often entwined with child labour issues. Child labour is a widespread phenomenon in the country, despite the existence of laws that prohibit it. About 1.6 million children are involved, with the majority (76%) aged 5-13 years. Participation rate (i.e. labour force divided by the total working-age population) is 40.4%, with a significant difference between girls (47.6%) and boys (36.1%) (International Labour Organization and Central Bureau of Statistics 2012). Discrimination of girls has also been related to the practice of sex-selective abortion (Lamicchane et al., 2011) and persistence in remote districts of traditional yet illegal superstitions (Joshi, 2015, Namasivayam et al., 2012).

At a worldwide level, few studies have dealt with gender disparity through means of parasite epidemiology (Parraga et al., 1996, Curtale et al., 2007, Sevilimedu et al., 2016, Goodburn, 2014). Published work in Nepal has so far reported prevalence estimates for the general population (Devleesschauwer et al., 2014) but never addressed the theme of spatial or social disparity. With the World Health Organization (WHO) considering children, women, and specific adult groups (e.g. field workers) as at-risk populations for IPIs (World Health Organization 2012), the present study aimed to provide an alternative report of IPI prevalence data for Nepal, investigating the role of gender, age and dwelling area (i.e. urban vs rural) on the risk of infection.

Materials and Methods

Search strategy and study selection

Intestinal parasitic infection prevalence data for the Nepalese population were retrieved after systematic review of national (Nepalese) and international peer-reviewed sources and grey literature. Both online and offline items were consulted. The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach (Liberati et al., 2009). The PRISMA checklist is provided as Supporting Material S1. The search question was constructed adapting the PICO strategy (Institute of Medicine 2011) as follows: Population = Nepalese population; Intervention = dwelling in rural areas; Control/Comparison = dwelling in urban areas; Outcome = different IPI prevalence. The search query combined the keywords 'Nepal' AND 'prevalence' to any one of the following elements: 'intestinal parasite?' OR 'soil transmitted helminth?' and their respective acronyms 'IPI' OR 'STH'. The SFX-MetaLib-based search engine AIRE of Padua University was used for simultaneous searches of PubMed, CINHAL, ScienceDirect, Scopus and Web of Science records. National journals and bulletins were searched with the support of the National Zoonoses and Food Hygiene Research Center (NZFHRC) and the Kantipur College of Medical Sciences of Kathmandu (Nepal). Relevant dissertations were retrieved from the library of Tribhuvan University of Kirtipur (Nepal): paper catalogues were manually consulted and digital records searched with the same query used for peer-reviewed literature.

Eligibility criteria

Adopted eligibility criteria enabled the selection of community-based studies, with year of publication >2000 and a shared laboratory protocol for the detection of parasites in stool samples (i.e. direct saline and Lugol's iodine wet-mount). Hospital surveys were excluded, as well as prevalence estimates carried out after deworming interventions or among non-representative subpopulations.

Statistical analysis

IPI prevalence data were extracted from included works by a single investigator with good knowledge of the Nepalese context. Prevalence for the general population was calculated as previously described by Rim and colleagues (Rim et al., 2003). Prevalence was then stratified by sex and after the following age classes: total population, adults aged ≥16 years and children aged 0-15 years. Moreover, land use (urban vs rural) of each survey site was considered as a geospatial variable. Differences among prevalence proportions were calculated with 95% confidence interval (CI) and significance level for odds ratios (ORs) evaluated with chi-square test. EpiInfo™ 7.2.2.6 software was used for statistical analysis (Dean et al., 2011).

Survey site geospatial information

For each survey site, univocal latitude and longitude were established to allow geopositioning. Geographic coordinates were assigned *ex post* with GPS coordinates finder online software (GPS coordinates finder online software 2018). Land use was derived from a land use map of Nepal, derived from satellite surface imagery (International Steering Committee for Global Mapping 2015) and survey sites were assigned to either the urban (U)

Table 1
List of survey sites. Coordinates are reported in decimal degrees (dd) and land use is marked either as urban (U) or rural (R).

Survey site	District	City / Village	Latitude	Longitude	Land use
1	Baglung	Baglung Bazar	28,2668	83,5975	U
2	Bara	Kalaiya	27,0304	85,0035	R
3	Bardiya	Rajapur	28,4195	81,1282	R
4	Bhaktapur	Thimi	27,6783	85,3769	U
5	Bhaktapur	Bhaktapur	27,6764	85,4350	U
6	Bhaktapur	Bhaktapur	27,6698	85,4229	U
7	Bhaktapur	Bhaktapur	27,6692	85,4304	U
8	Bhaktapur	Bhaktapur	27,6761	85,4281	U
9	Chitwan	Chitrasar	27,5962	84,5044	R
10	Chitwan	Ratnanagar	27,6181	84,5158	R
11	Chitwan	Birendranagar	28,5860	81,6177	R
12	Dadeldhura	Amargadhi	29,3010	80,5880	R
13	Gorkha	Taklung	27,9082	84,6194	R
14	Ilam	Kanyam	26,8632	88,0799	R
15	Kailali	Malakheti	28,7953	80,5254	R
16	Kapilvastu	Chanai	27,6554	82,8783	R
17	Kaski	Lekhnath	28,1506	84,0766	R
18	Kaski	Dhikur Pokhari	28,2826	83,8512	R
19	Kathmandu	Kuleshwor	27,6909	85,2963	U
20	Kathmandu	Mulpani	27,7105	85,3989	U
21	Kathmandu	Kathmandu	27,6916	85,3424	U
22	Kathmandu	Kathmandu	27,7028	85,3013	U
23	Kathmandu	Kathmandu	27,7170	85,3547	U
24	Kathmandu	Kathmandu	27,7228	85,3831	U
25	Kathmandu	Kathmandu	27,7017	85,3034	U
26	Kathmandu	Kathmandu	27,7096	85,3164	U
27	Kathmandu	Gagal	27,7524	85,4464	R
28	Kathmandu	Kirtipur	27,6596	85,2879	U
29	Kathmandu	Kirtipur	27,6622	85,2526	U
30	Kathmandu	Kirtipur	27,6716	85,2880	U
31	Kathmandu	Kirtipur	27,6698	85,2813	U
	Kathmandu	Kirtipur	27,6698	85,2813	U
	Kathmandu	Kirtipur	27,6698	85,2813	U
32	Kathmandu	Kirtipur	27,6747	85,2740	U
	Kathmandu	Kirtipur	27,6747	85,2740	U
	Kathmandu	Kirtipur	27,6747	85,2740	U
33	Kathmandu	Kirtipur	27,6710	85,2820	U
	Kathmandu	Kirtipur	27,6710	85,2820	U
	Kathmandu	Kirtipur	27,6710	85,2820	U
34	Lalitpur	Khokana	27,6430	85,2954	R
35	Lalitpur	Patan	27,6618	85,3156	U
36	Morang	Biratnagar	26,4538	87,2738	U
37	Nawalparasi	Pragatinagar	27,6807	84,1898	R
38	Nawalparasi	Gaindakot	27,7362	84,3927	R
39	Parsa	Birgunj	27,0387	84,8703	U
40	Parsa	Parsauni	27,0342	84,9236	R
41	Rautahat	Mithuawa	26,8820	85,3161	R
42	Sunsari	Dharan	26,7964	87,2796	U
43	Sunsari	Dharan	26,8316	87,2834	U

or rural (R) category after reference criteria; rural was considered as those points >15 km from each urban extent edge (Pullan and Brooker, 2012). Mapping of survey sites and graphical rendering was carried out with Epi Info^{TM} EpiMap tool (Dean et al., 2011).

Results

Survey sites and population size

The systematic literature search identified 45 works: 17 peer-reviewed papers (Adhikari et al., 2008, Tiwari et al., 2013, Pooja Regmi et al., 2014, Moffat, 2003, Khanal et al., 2011, Shrestha et al., 2012, Tandukar, 2013, Yong, 2000, Gyawali, 2009, Parajuli et al., 2014, Shakya, 2012, Shrestha, 2007, Parajuli, 2009, Sharma et al., 2004, Shrestha and Maharjan, 2014, Chongbang et al., 2016), 20 MSc dissertations and eight NGO technical reports. A flow diagram of the search process and reference list of grey literature items are provided as Supporting Material S2 and S3, respectively. Selected works provided data from 9,990 participants (4,931 males and 5,059 females). Stool samples were collected in 43 distinct survey sites, which are listed in Table 1 and depicted by Figure 1.

The adult population was represented by 862 individuals (118 males, 744 females) and paediatric samples counted 9,128 items (4,813 males and 3,735 females). Survey sites were located in 18 different districts of the country: 18 of them were classified after land use as rural and 25 as urban. No study was carried out in the Himalayan region (Northern districts); this is possibly due to extremely low population density (Central Bureau of Statistics 2012) and, possibly, ecological variables (e.g. temperature, aridity) preventing the transmission of some parasites (Central Bureau of Statistics 2014, Baldovin et al., 2019).

Prevalence of intestinal parasites

Identified intestinal parasite species included: helminths *Ascaris lumbricoides, Trichuris trichiura*, hookworm, *Enterobius vermicularis, Fasciola hepatica, Fasciola buski, Hymenolepsis nana, Hymenolepsis*

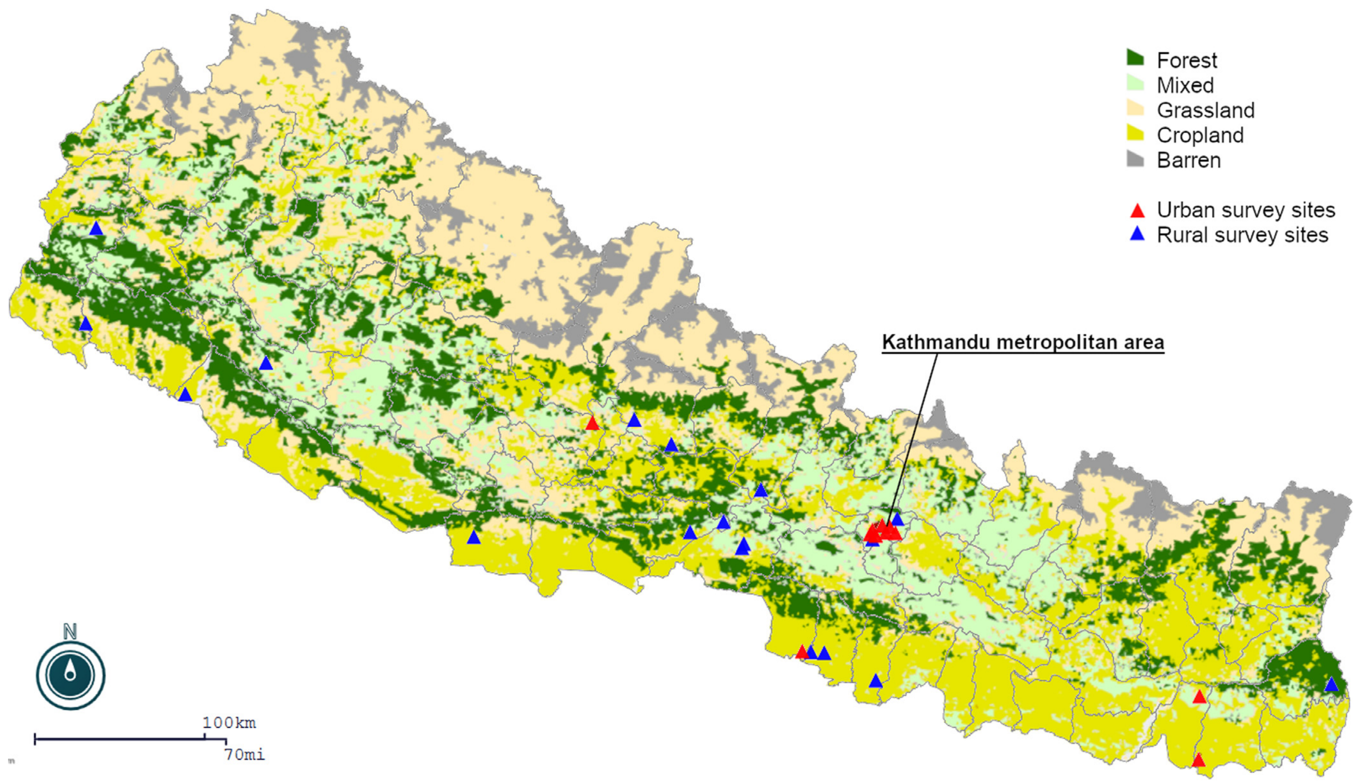

Figure 1. Land use map of Nepal and survey sites.
The 43 survey sites are represented by a red triangle (urban areas) or a blue one (rural settlements). Survey sites within Kathmandu metropolitan area are marked with a single symbol for better graphic rendering.

Table 2
IPI prevalence (%) for the Nepalese population. Proportions are given for the general population and with sex and spatial stratification.

		Tot	Males	Females
Country level	general population	37,6	37,0	38,2
	adults	53,2	54,2	53,1
	children	36,1	36,6	35,6
Urban	general population	32,4	33,4	31,4
	adults	35,5	41,7	34,3
	children	32,3	33,3	31,2
Rural	general population	52,3	48,6	55,2
	adults	59,2	59,8	59,1
	children	50,0	47,8	52,7

diminuta, Strongyloides stercoralis, Taenia spp. and *protozoa Blastocystis hominis, Cyclospora cayetanensis, Entamoeba coli, Entamoeba histolytica, Entamoeba hartmanni, Endolimax nana,* and *Giardia intestinalis*. However, since disaggregated (i.e. species-specific) data were only available for a limited number of works, the present study only considered prevalence for "any IPI"; prevalences are presented in Table 2. ORs and CIs were calculated for comparison between urban and rural survey sites and between males and females (Table 3). IPI prevalence for the general population was 37.6%, with a slight difference that did not achieve statistical significance between males (37.8%) and females (38.2%). Stratification by age class yielded the following prevalence: 53.2% for adults (M = 54.2%; F = 53.1%) and 36.1% for children (M = 36.6%; F = 35.6%). Significant difference between adults and children was corroborated by OR (1.45) and 95% CI (1.21-1.74), with $p < 0.001$. Similar findings of lower IPI prevalence in children were also observed in urban and rural areas. When introducing spatial stratification by land use, the following prevalences were obtained: total population 32.4% (U) and 52.3% (R); adults 35.5% (U) and 59.2% (R); children 32.3% (U) and 50.0% (R). Differential prevalences between urban and rural populations were significant at $p < 0.001$ in each age class. Moreover, statistical significance for differential IPI prevalence between sexes was obtained in rural areas for the total population (M 48.6%; F 55.2%, with $p < 0.001$) and children (M = 47.8%; F = 52.7%, with $p < 0.029$), but neither for adults nor in urban areas.

Discussion

At a country level, IPI prevalence for the Nepalese general population was 37.6%. The first significant difference was found in the comparison between age classes, with prevalence in adults being more than 15 percentage points higher than in children. To explain this point, WHO data on preventive chemotherapy (PC) interventions in Nepal can be considered (World Health Organization 2015). Nepal is targeted by PC for soil-transmitted helminthiasis (STHs), with a total of 7,647,361 children requiring deworming. Currently, 51.8% of them are receiving biannual treatment. PC is based on single-dose albendazole (400 mg) administration (World Health Organization 2017). Broad-spectrum deworming can

Table 3
Statistical significance of differential prevalence rates. Odds-ratios (ORs) and 95% confidence intervals (CI) are reported along with significance level of the chi-square test. Data are always reported for the general population and by age-class, i.e. adults and children groups. NS – not significant p-value.

Comparison 1: males vs females			
	OR	95% CI	2-tailed p
general population	0.95	0.88 - 1.03	0.220
adults	1.05	0.71 - 1.55	0.810
children	1.04	0.96 - 1.13	0.350
Comparison 2: urban vs rural dwellers			
	OR	95% CI	2-tailed p
general population	0.49	0.44 - 0.53	<0.001
adults	0.38	0.27 - 0.52	<0.001
children	0.48	0.43 - 0.53	<0.001
Comparison 3: males vs females, living in urban areas			
	OR	95% CI	2-tailed p
general population	1.10	0.99 - 1.21	0.060
adults	1.37	0.66 - 2.84	0.390
children	1.10	1.00 - 1.21	0.056
Comparison 4: males vs females, living in rural areas			
	OR	95% CI	2-tailed p
general population	0.77	0.66 - 0.90	0.001
adults	1.02	0.64 - 1.64	0.920
children	0.82	0.67 - 0.98	0.029

thus be hypothesised twice a year, at least for helminths and sensitive protozoa such as *Giardia* (World Health Organization 2015). Lower IPI prevalence in children in comparison with adults can thus be ascribed to targeted PC in schools, together with enhanced awareness of pupils and better hygiene of the scholastic environment. Nevertheless, chronic re-infection is likely to continue until issues related to the water-sanitation-health (WASH) trinomial are fully addressed, deworming guidelines are improved in favour of mass drug administration, and a community-led total sanitation approach is implemented, as suggested by some recent reviews (Clarke et al., 2017, Hurlimann et al., 2018, Ásbjörnsdóttir et al., 2017).

Whether IPI prevalence results are higher in children or adults could seem to be a rather controversial topic, since similar studies have reported contrasting findings. For instance, a survey carried out in Chachoengsao Province, Thailand, also described higher prevalence in adults (Suntaravitun and Dokmaikaw, 2018), whereas two studies from India described a higher IPI infection rate among children if compared with adults and elderly people (Marothi and Singh, 2011, Dhanabal et al., 2014). However, it should be taken into account that the Global Parasite Control Initiative started in 2000 in the Greater Mekong subregion (i.e. Thailand, Cambodia, Laos, Myanmar, and Vietnam), similar to Nepal (Jimba et al., 2005), whilst in India mass deworming based on state-specific prevalence was recommended in 2009 and the first National Deworming Day was actually conducted in 2015 (Child Health Division 2015).

Although the role of polyparasitism in affecting the burden of parasitic infections has been previously highlighted (Pullan and Brooker, 2008), it could not be evaluated in the present work as co-infection data were not available.

Significant differences were also found in the IPI prevalence of urban and rural areas, with the rural population reporting a higher proportion of infected people. This finding is in accordance with a previous study carried out on school children in the Kaski District of Western Nepal (Chandrashekhar et al., 2005). In addition, urban/rural disparities were recognised by a major meta-analysis on STHs epidemiology as influencing national prevalence, although they were too weak to be standardised on a global scale (Pullan et al., 2014). In fact, literature reports that some single parasite species can exhibit higher prevalence in urban areas (e.g. *A. lumbricoides* (Pullan and Brooker, 2012)); however, as general rule for Nepal, dwelling in urban areas should be considered as a protective factor against IPIs.

When considering only the rural population, IPI prevalence in females was significantly 5 percentage points higher than in males. In addition, with regard to age groups, this difference was fully explained by the children's group, whereas adults were not affected by gender-biased prevalence.

The observed differences in the IPI prevalence between male and female children is the result of gender disparity in the form of discrimination against school enrolment of girls. In rural areas, among children who never attended school, most were girls (15% of working girls). Moreover, drop-out rate of girls from schools was higher than their male counterparts and has been especially linked to poverty-related constraints of rural areas (Central Bureau of Statistics 2011, World Health Organization 2017). In addition, girls work more and for longer hours in the fields in comparison with their male counterparts (International Labour Organization 2011). Hence, two factors simultaneously modify risk of infection for girls: on the one hand, agricultural work enhances exposure to IPI and, on the other hand, lower school attendance deprives them of periodic PC fruition. In wider terms, these dynamics seem capable of increasing the risk of infection not only for IPIs, but also for a number of other soil- and waterborne diseases. Prevalence is similar in adults since they eventually share levelled living standards and exposure is intuitively equivalent for agricultural workers of both sexes, despite the higher proportion of women working in the fields (Gartaula et al., 2010).

No significant difference between genders was found in urban areas. Literacy and education indicators for Kathmandu Valley (i.e. the widest urban area of Nepal) consistently show an almost negligible gender gap (Central Bureau of Statistics 2014). Although no significant difference was found between males and females of any age in urban areas (Table 2), adult males could possibly represent an at-risk group for IPIs. School attendance for both genders was higher in urban areas compared with rural ones, and the social gender gap was less pronounced (Central Bureau of Statistics 2014, Bhattarai et al., 2020). A comparable prevalence in school-aged children of both sexes should therefore not be unexpected. However, differential separation of gender roles increases with age, so that adult males and females practice distinct activities in their daily routine. Differential environmental/occupational exposure possibly represents the factor most likely capable of explaining the hinted – yet not statistically significant – difference in IPI prevalence among adults in urban areas. Further insight is provided by the comparison of the above results with some macro-regional studies. A survey carried out in Ujjain, Madhya Pradesh, in central India (Marothi and Singh, 2011), describes how higher prevalence was seen in the rural population (23.1%) in comparison with urban dwellers (20.2%) and in females (27.4%) rather than males (18.2%). Another Indian study from Chennai, on the Eastern coast, also showed higher prevalence among females, although in a urban context (Dhanabal et al., 2014). In a study from Bang Khla, Chachoengsao Province, in Thailand (Suntaravitun and Dokmaikaw, 2018), males had a significantly higher prevalence rate (22.7%) of parasitic infections than females (11.8%). Moreover, balanced differences can be found in the work by Ri and colleagues (Rim et al., 2003), carried out in Laos, in which total IPI prevalence in males (62.3%) was not significantly different to that of females (61.4%). Unfortunately, a detailed social and potential gender-gap analysis in the above areas was not provided in these epidemiological reports, so the simplest and most plausible assumption is that there is no sex-predominance for IPIs, but rather prevalence relates to the daily activity of individuals.

Conclusions

IPIs are endemic in Nepal and represent a major public health problem for the local population, with an overall prevalence estimate of 37.6%. The present study further investigated whether sociodemographic factors can possibly affect the risk of IPI infection in some vulnerable groups (e.g. women, children and rural dwellers), through the spatial, age and sex stratification of prevalence data. Critical evaluation of significant differences among prevalence rates suggests the following:

- At a country level, children are less infected than adults. This could be ascribed to the efficient targeted PC and educational programs currently implemented in Nepalese schools.
- IPI prevalence is higher in rural Nepal, compared with urban areas. Dwelling in cities seems to be a protective factor against IPIs, although specific assessment of degraded peri-urban areas (e.g. slums) should be carried out.
- Among dwellers of rural Nepal, school-aged girls are more infected than boys. Consistently, lower school attendance and enrolment in field work of young girls preclude PC fruition, less time spent in safe environments and enhanced "occupational" exposure to IPI.

The above interpretation deals with a country still dealing with considerable inner disparities. Lower socioeconomic conditions of rural areas eventually stress gender inequality, so that higher IPI prevalence among girls can be seen as an epidemiological reflection of the many complex dynamics that ultimately affect and disadvantage women's health and life.

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Conflicts of Interest: Nil.

Ethics and consent: This research is exempt from the Institutions direct ethics approval since data were collected and analysed from previously published works: consent and approval had already been obtained by the original investigators. Moreover, only pseudo-anonymized data were used, precluding the identification of participants.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2021.06.041.

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