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Original Article

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# Travel-related giardiasis: incidence and time trends for various destination countries

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## Abstract

**Background:** Giardiasis is a common gastrointestinal illness in travellers. Data on the actual giardiasis risk of travellers to different travel destinations are scarce. We aim to estimate the risk of giardiasis in travellers from Germany by destination country and region.

**Methods:** We analysed travel-related giardiasis cases, their countries and regions of exposure and the age and sex distribution of cases reported in 2014–19 in Germany. We defined a travel-related giardiasis case as a laboratory-confirmed (i.e. positive microscopy, antigen test or nucleic acid test) symptomatic individual with outbound travel abroad within 3–25 days before symptom onset. Based on the number of reported cases per exposure country and UNWTO travel data for Germany, we calculated the number of travel-related giardiasis cases per 100 000 travellers and compared the incidence in 2014–16 and 2017–19 to identify potential trends.

**Results:** In 2014–19, 21 172 giardiasis cases were reported in Germany, corresponding to an overall incidence of 4.3 per 100 000 population. Of all cases, 6879 (32%) were travel-related with a median age of 34 [interquartile range (IQR): 25–50], 51% were male. Southern Asia was the most frequently reported exposure region and had the highest incidence in travellers (64.1 per 100 000 returning travellers) in 2017–19, followed by Latin America (19.2) and Sub-Saharan Africa (12.9). We observed statistically significant decreasing trends for Southern Asia and Sub-Saharan Africa. Latin America was the only region with a statistically significant increasing trend.

**Conclusions:** Almost one-third of recent giardiasis cases in Germany were travel-related. Giardiasis incidence in travellers differs greatly depending on the destination region. Decreasing trends in many regions might be due to improvements in food hygiene or travel conditions. Our results may inform medical consultation pre and post patient's travel.

**Key words:** Giardiasis, travel-related illness, infectious disease epidemiology, surveillance

## Introduction

Globally, *Giardia duodenalis* (syn. *G. lamblia*, *G. intestinalis*) is one of the most common human protozoan enteropathogens and a leading cause of gastroenteritis.[1]

Giardiasis is also one of the top diagnoses in ill travellers presenting in travel clinics in Europe.[2] Transmission occurs faecal–orally through contaminated food and water or direct person-to-person contact. Inadequate hygiene conditions and close person-to-person contact are known as risk factors for infection.[3] The majority of acute infections in immunocompetent humans is self-limited with gastrointestinal symptoms including diarrhoea, stomach ache and bloating lasting for 1–3 weeks.[4] However, persistent abdominal symptoms and long-term consequences of infection like extra-intestinal manifestations, impaired child growth and irritable bowel syndrome can occur.[5,6] In Europe, giardiasis is often considered to be a mainly travel-related

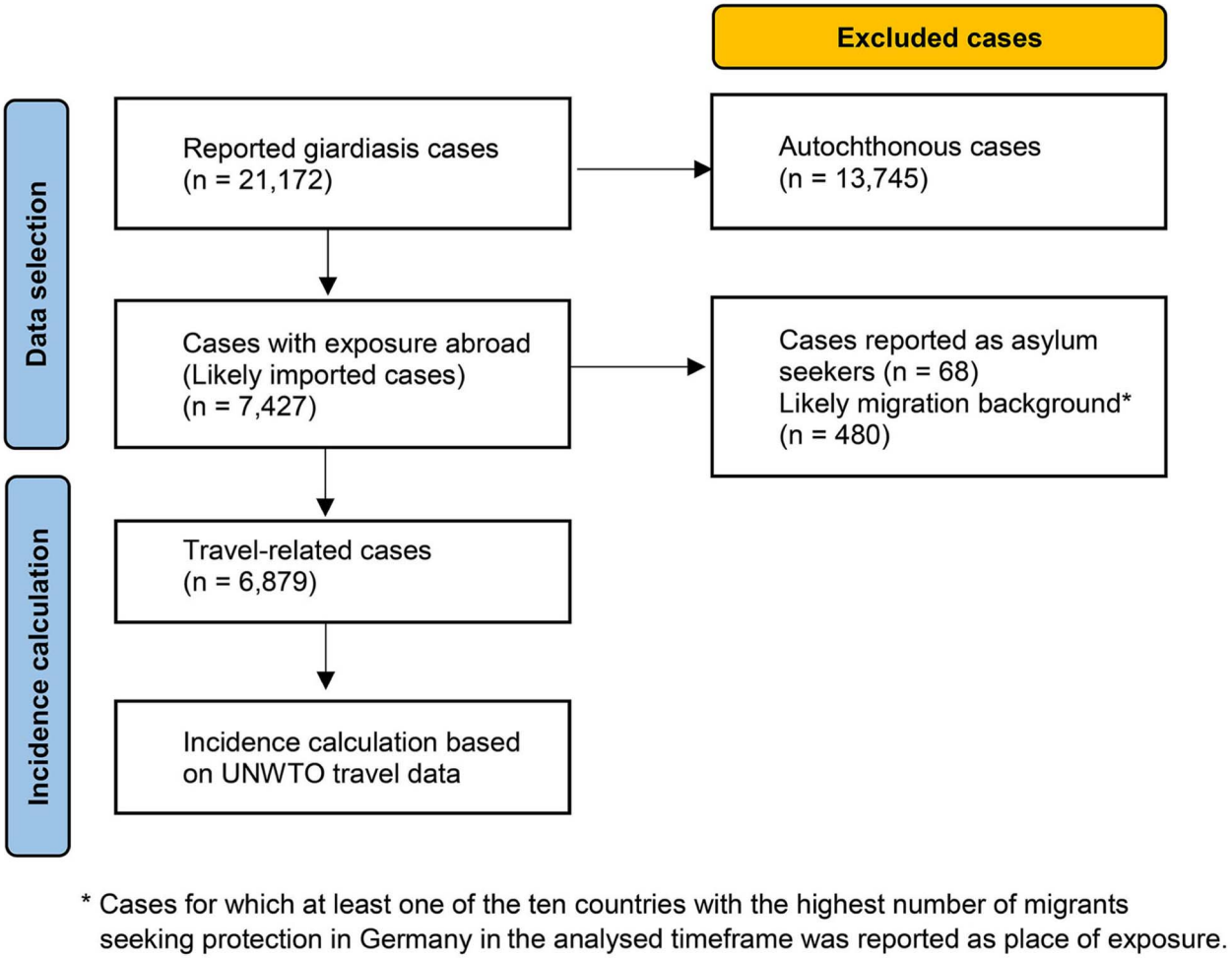


**Figure 1.** Data selection process for travel-related cases, Germany, 2014–19

disease.[2,7,8] Before the period of disrupted travel during the COVID-19 pandemic, about one-third of the reported cases in Germany likely acquired the infection abroad,[9] which is in the range of imported infections in other European countries.[10,11]

For Germany, the countries most frequently reported by travellers as likely places of exposure are published annually by the Robert Koch Institute, the national public health institute.[12] However, without an appropriate denominator, i.e. the number of people travelled, these figures do not accurately reflect the risk of infection. Data on the actual giardiasis incidence in travellers are scarce.

Thus, our aim was to estimate giardiasis incidence and time trends in travellers returning to Germany by destination country and region to provide guidance for pre-travel advice and medical care of symptomatic returning travellers.

## Methods

### Case definitions

Giardiasis is a notifiable disease in Germany. Laboratory confirmed cases are reported to the local public health department by the respective laboratories. Clinical and epidemiological information, such as the likely place of exposure, is requested by the local health department from the patient or the treating physician. The local health department transmits the anonymized case data to the state health department, from which the data are further transmitted to the Robert Koch Institute. According to the national case definition in Germany, a confirmed case is a patient with at least one of the following symptoms: diarrhoea, abdominal pain or flatulence and laboratory confirmation (antigen test, microscopy or nucleic acid test).

For the purpose of this study, we defined a travel-related giardiasis case as an individual fulfilling the surveillance case definition and with foreign travel in the 3–25 days before symptom onset. To match the denominator (travellers) in the incidence calculation, we excluded cases reported as asylum seekers and cases for which at least 1 of the 10 countries with the highest number of migrants seeking protection in Germany in the analysed timeframe was reported as place of exposure (Figure 1).[13] We applied the Standard Country or Area Codes for Statistical Use (M49 standard) of the United Nations for the classification of countries, regions and continents.[14]

### Descriptive analysis of surveillance data

We analysed the absolute and relative numbers of travel-related giardiasis cases, the associated likely countries and regions of

exposure and the age and sex distribution of travel-related cases reported in 2014–19 in Germany. For the analysis of the age and sex distribution of travel-related cases, we included cases with a single exposure region only. All other cases were included in the category 'Multiple'.

### Travel data

For information on the number of travellers from Germany to countries abroad, we used the World Tourism Organization's (UNWTO) database, which provides annual tourism data.[15] The database contains data on arrivals of travellers from a reference country (here: Germany) supplied by each destination country.[16]

### Calculation of incidence in travellers

For returning travellers reported as giardiasis cases, we calculated the incidence proportion (cases per 100 000 travellers) by exposure country and aggregated by region and continent for 2014–16 and 2017–19 using the following formula:

$$\frac{\text{Number of reported giardiasis cases in Germany with country X as likely place of exposure}}{\text{Number of reported travellers from Germany to country X}} \times 100,000$$

Up to four countries could be reported as places of exposure. If multiple places of exposure were reported, all countries were equally included for the calculation of the incidence in travellers. While this is a potential source of bias leading to overestimation of incidence for some countries, <5% of cases were reported with multiple foreign exposure countries, thus we consider the impact as rather low. If a sub-national place, a region or continent was reported, we reclassified the information to the respective country level, if possible, or excluded the case.

We calculated the 95% confidence interval (CI) for the incidence in travellers under the assumption that the reported number of cases is Poisson-distributed and independent between countries.

We assessed time trends, comparing the incidence in travellers in 2017–19 and 2014–16. We considered a trend to be statistically significant if the two 95% CI did not overlap. To minimize the bias for countries with very little data or imprecise estimates available, we excluded (i) countries with missing data in the surveillance data or the travel data and (ii) countries for which the criterion *CI-width/incidence in travellers* > 2 was fulfilled for the incidence calculation.

We used MS Excel, R version 4.1.3 and RStudio version 2022.07.2+576 for data analysis. We created the map using the tmap package[17] and Natural Earth data.

## Results

### Epidemiology of travel-related giardiasis cases, 2014–19

In 2014–19, 21 172 acute giardiasis cases were reported in Germany, corresponding to an incidence of 4.3 per 100 000 population. For 7427 (35%) of those, at least one exposure country other than Germany was reported. Of these likely imported cases, 6879 cases (93%) fulfilled our case definition of travel-related cases (32% of all cases). The proportion of travel-related cases of all reported giardiasis cases remained relatively stable over time with 30% in 2015 and 2016 and 36% in 2018.

### Reported places of exposure

In 2014–19, 6691 valid exposure locations were reported. The most frequent ones were as follows:

- Southern Asia ($n = 1911$, 29%), in particular India ($n = 1580$, 24%) and Nepal ($n = 149$, 2%)
- Latin America and the Caribbean ($n = 1171$, 18%), in particular Colombia ($n = 203$, 3%) and Mexico ($n = 149$, 2%)
- Sub-Saharan Africa ($n = 918$, 14%), in particular United Republic of Tanzania ($n = 169$, 3%) and Kenya ($n = 86$, 1%)
- Southern Europe ($n = 777$, 12%), in particular Spain ($n = 299$, 4%) and Italy ($n = 209$, 3%)
- South-eastern Asia ($n = 714$, 11%), in particular Thailand ($n = 304$, 5%) and Indonesia ($n = 133$, 2%).

### Age and sex distribution

The median age of all travel-related cases reported in 2014–19 was 34 (IQR: 25–50), with most cases reported in 20–39-year-olds (47%). Fifty-one percent were male. Of 5867 travel-related cases with reported hospitalization status, 416 cases (7%) were hospitalized due to giardiasis.

Giardiasis cases returning from Australia and New Zealand were youngest, with a median age of 30, whereas cases exposed in Central Asia had the highest median age of 43.5 (Table 1). Cases exposed in Eastern Europe had the highest proportion of male cases (66%).

### Incidence map

We mapped 132 countries and categorized them by incidence of giardiasis in travellers in 2014–19 (Figure 2). Nearly one-third of the countries (29%, 39/133) had 0–1 giardiasis cases per 100 000 travellers. In total 14 countries had > 50 cases per 100 000 travellers and were located in Southern Asia (Bangladesh, India, Nepal), Central Asia (Tajikistan), Latin America (Colombia), Sub-Saharan Africa (Benin, Burkina Faso, Congo, Gambia, Madagascar, Mali, Togo, Uganda) and Melanesia (Solomon Islands).

### Incidence trend in travellers (2014–16 vs 2017–19)

Southern Asia had the highest incidence in travellers in 2014–16 and 2017–19 with 81.9 and 64.1 cases per 100 000 travellers (Figure 3, Table 2).

In 2017–19, the incidence on the regional level in travellers varied >600-fold with 0.1 cases per 100 000 travellers in Western Europe to 64.1 in Southern Asia, followed by Latin America (19.2) and Sub-Saharan Africa (12.9). In 10 out of 14 world regions, the incidence decreased in 2017–19 compared with 2014–16, with a statistically significant decreasing trend for Southern Asia (CI 2014–16: 76.77–87.24; CI 2017–19: 59.85–68.51) and Sub-Saharan Africa (CI 2014–16: 15.68–19.68; CI 2017–19: 11.39–14.54). The only region with a statistically significant increasing trend was Latin America (CI 2014–16: 14.25–17.43; CI 2017–19: 17.63–20.97).

**Table 1.** Age and sex distribution of travel-related giardiasis cases by exposure region, Germany, 2014–19

| Region of exposure[a] | Cases (*n*) | Median age | IQR[b] | Proportion of male cases (%) |
|---|---|---|---|---|
| Australia and New Zealand | 15 | 30.0 | 14.0–39.0 | 53.3 |
| Central Asia | 38 | 43.5 | 28.0–60.3 | 55.3 |
| Eastern Asia | 55 | 41.0 | 31.0–54.0 | 65.5 |
| Eastern Europe | 118 | 34.0 | 23.3–45.0 | 66.1 |
| Latin America and the Caribbean | 1068 | 31.0 | 24.0–48.0 | 46.5 |
| Melanesia | 3 | 54.0 | 36.5–62.5 | 33.3 |
| Northern Africa | 358 | 39.5 | 26.0–55.0 | 45.3 |
| Northern America | 119 | 39.0 | 27.5–50.0 | 59.7 |
| Northern Europe | 40 | 40.5 | 27.8–53.3 | 62.5 |
| South-eastern Asia | 641 | 36.0 | 28.0–49.0 | 59.0 |
| Southern Asia | 1815 | 30.0 | 24.0–47.0 | 47.2 |
| Southern Europe | 699 | 40.0 | 28.0–53.0 | 62.5 |
| Sub-Saharan Africa | 855 | 39.0 | 25.0–53.0 | 41.5 |
| Western Asia | 123 | 35.0 | 25.0–48.0 | 63.4 |
| Western Europe | 174 | 38.0 | 24.3–48.0 | 64.4 |
| Multiple | 245 | 37.0 | 25.0–52.0 | 56.3 |

[a]Only cases with a single exposure region are displayed per regional category, all other cases are included in category 'Multiple'. [b]Interquartile range (IQR)

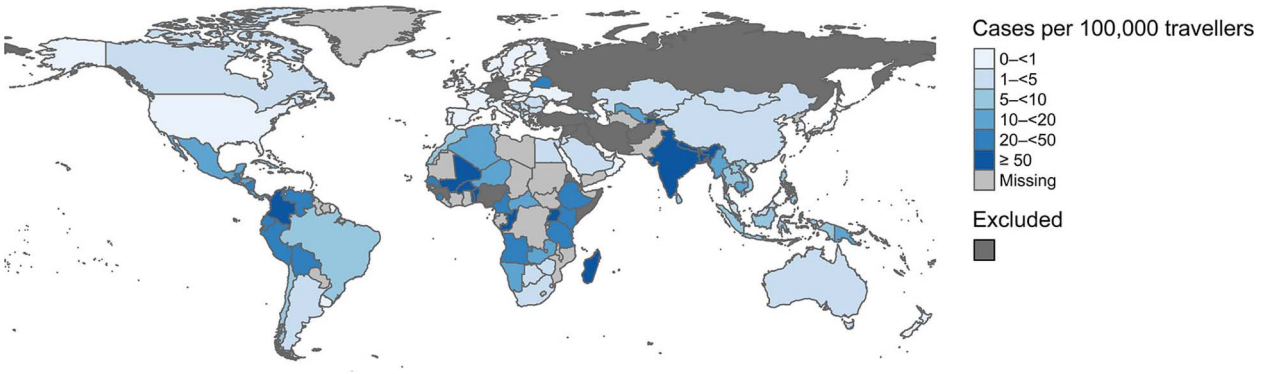


**Figure 2.** Notified cases of travel-related giardiasis per 100 000 travellers by travel region, Germany, 2014–19. Note: The number of cases per 100 000 travellers per country is based on all years with both surveillance and travel data available and at least one exposed case. Excluded countries: Germany as reference country and top-10 countries with the highest number of migrants seeking protection in Germany in 2014–20. The presentation of this map does not imply the expression of any opinion whatsoever on the part of the authors concerning the legal status of any country, territory, region, city or of its authorities, or concerning the course of its frontiers or boundaries. For more information about the disputed boundaries policy of the geographical source data, see: https://www.naturalearthdata.com/about/disputed-boundaries-policy/.

## Discussion

Our study provides the first estimate of travel-related giardiasis incidence in travellers from Germany to various countries and regions.

By using travel data as a denominator to calculate travel-related giardiasis incidence, we were able to estimate the risk of giardiasis for travellers by destination region and country and assess time trends.

Our results show that several countries which are not among the top mentioned exposure countries had a high incidence in travellers, e.g. Bangladesh, Madagascar and Burkina Faso, while we found a very low incidence for popular travel destinations and frequently reported exposure countries in Europe such as Spain and Italy. Other countries such as India, Nepal and Colombia were among the 15 most frequently reported exposure countries in 2017–19 and had a comparatively high incidence of > 50 cases per 100 000 travellers. We observed a statistically significant rising incidence trend for Latin America, whereas trends for most other regions of the world decreased, potentially due to improvements in food hygiene or travel conditions.

Previous studies (e.g. Germany, 2000,[18] Canada, 2006–12[19]) showed relatively high counts of giardiasis among travellers returning from Southern Asia. However, not considering an appropriate denominator (number of travellers per destination) likely leads to an overestimation of the risk of giardiasis for popular destinations, whereas the risk for less visited countries is likely to be underestimated. We found a similar geographical risk distribution as a Swedish study from 2005 that applied a similar approach using travel data.[10] Our estimated incidences were, however, overall lower than the risk estimate by Ekdahl and Andersson, which might be due to differences in travel behaviour or in the travel data.

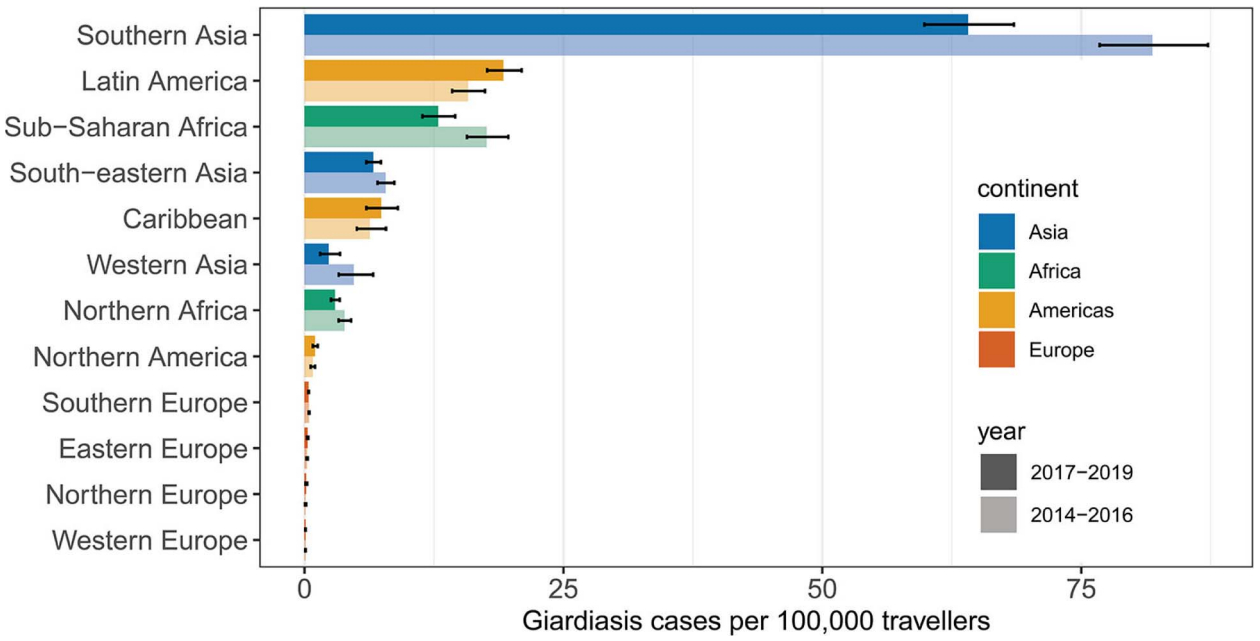


**Figure 3.** Reported travel-related giardiasis cases per 100 000 travellers (bars) and 95% CI (error bars) by world region, Germany, 2014–16 vs 2017–19. Note: Regions displayed with > 1 included country; number of included countries per region: Southern Asia ($n = 4$), Sub-Saharan Africa ($n = 11$), Latin America ($n = 11$), South-eastern Asia ($n = 8$), Caribbean ($n = 2$), Western Asia ($n = 2$), Northern Africa ($n = 3$), Northern America ($n = 2$), Southern Europe ($n = 9$), Eastern Europe ($n = 5$), Western Europe ($n = 3$).

Although we were not able to assess immunosuppression status (not available in the surveillance dataset), immunocompromised patients can have a higher risk of severe giardiasis and treatment failure.[20] Furthermore, emerging nitroimidazole-refractory giardiasis has been described for Germany and other low-prevalence countries, especially in returning travellers from Southern Asia.[20–23] Linking clinical and epidemiological information is thus important to accurately assess the risk of travel-related giardiasis and treatment failure.

We focused on data prior to the COVID-19 pandemic, as case numbers in Germany declined by ∼40% in 2020[24] and travel restrictions largely reduced the number of international travellers and might have introduced bias regarding the travel countries. To monitor the development of the risk for travel-related giardiasis, the data should be updated in the future. This is especially important as travel behaviour after the COVID-19 pandemic could differ from pre-pandemic behaviour.

For a more specific risk assessment (i) for subgroups of travellers, e.g. stratified by age, sex, travel duration and travel behaviour, and (ii) on a sub-national and local level in the travel destination countries, further studies are needed.

## Limitations

The travel data provided by UNWTO are a well-established comprehensive database that relies on multiple sources of information. However, it does have its limitations. Not all countries provide data annually and based on the same information source which may slightly limit the comparability of incidence in travellers for some countries.

Surveillance data come with well-known limitations, of which underascertainment and underreporting of cases are likely the most relevant in our study leading to an underestimation of the actual incidence in travellers. As infection with *G. intestinalis* is a notifiable disease with a well-established case definition in Germany since 2001 and we used a large dataset, we consider the impact of other potential biases on our overall results as rather low. Due to the limitations of the available travel data, which only provide aggregated numbers, and the restricted scope of routine surveillance data, we were unable to provide further stratification of results by age, sex, sub-national region or mode and purpose of travel. Although our data hold relevance for other settings with relatively low endemicity, its generalisability should be subject to careful assessment (e.g. with regard to the typical travel behaviour of the respective population).

## Conclusions

More than one-third of the giardiasis cases in Germany from 2017–19 were travel-related, making pre-travel advice an important intervention to inform travellers of their individual risk and preventive measures, especially for those with a high risk of severe disease. Our study results can inform and contribute to a more risk-adapted travel advice, which we consider helpful in view of the vast incidence differences between countries and regions and in light of the emerging nitroimidazole-refractory giardiasis. Pre-travel advice for future travellers should also consider epidemiological trends such as the rising incidence we observed for Latin America. For a more specific risk assessment (i) for subgroups of travellers, e.g. stratified by age, sex, travel duration and travel behaviour, and (ii) on a sub-national and local level in the travel destination countries, further studies are needed.

**Table 2.** Number of travel-related giardiasis cases and cases per 100 000 travellers by continent, region and country of exposure, Germany, 2014–16 and 2017–19

| Continent/region/country of exposure | 2014–16 | | | 2017–19 | | | Ratio[a] | Trend[b,c] |
|---|---|---|---|---|---|---|---|---|
| | Number of travel-related cases | Incidence (cases/100 000 travellers) | 95% CI | Number of travel-related cases | Incidence (cases/100 000 travellers) | 95% CI | | |
| Asia | 1380 | 16.5 | 15.60–17.35 | 1252 | 13.1 | 12.40–13.86 | 0.8 | ▼* |
| *Southern Asia* | *955* | *81.9* | *76.77–87.24* | *857* | *64.1* | *59.85–68.51* | *0.8* | ▼* |
| Bangladesh | 12 | 449.6 | 232.32–785.37 | 14 | 376.8 | 205.97–632.12 | 0.8 | ▼ |
| India | 854 | 113.4 | 105.88–121.23 | 726 | 89.8 | 83.39–96.58 | 0.8 | ▼ * |
| Nepal | 68 | 116.8 | 90.66–148.01 | 81 | 78.3 | 62.22–97.37 | 0.7 | ▼ |
| Sri Lanka | 21 | 6.0 | 3.69–9.12 | 36 | 8.5 | 5.97–11.81 | 1.4 | ▲ |
| *Central Asia* | *8* | *41.6* | *17.97–82.01* | *6* | *11.3* | *4.16–24.67* | *0.3* | ▼ |
| Uzbekistan | 8 | 41.6 | 17.97–82.01 | 6 | 11.3 | 4.16–24.67 | 0.3 | ▼ |
| *South-eastern Asia* | *358* | *7.8* | *7.04–8.68* | *344* | *6.6* | *5.96–7.38* | *0.8* | ▼ |
| Cambodia | 41 | 14.3 | 10.25–19.38 | 47 | 15.1 | 11.08–20.06 | 1.1 | ▲ |
| Myanmar | 24 | 22.4 | 14.37–33.36 | 14 | 14.2 | 7.79–23.91 | 0.6 | ▼ |
| Indonesia | 57 | 9.0 | 6.83–11.69 | 76 | 9.3 | 7.31–11.61 | 1.0 | ▲ |
| Lao People's Democratic Republic | 9 | 9.4 | 4.30–17.85 | 6 | 8.3 | 3.06–18.13 | 0.9 | ▼ |
| Philippines | 11 | 4.7 | 2.34–8.39 | 20 | 7.1 | 4.34–10.98 | 1.5 | ▲ |
| Viet Nam | 23 | 4.9 | 3.12–7.38 | 34 | 5.3 | 3.68–7.42 | 1.1 | ▲ |
| Malaysia | 17 | 3.9 | 2.28–6.28 | 19 | 5.2 | 3.10–8.04 | 1.3 | ▲ |
| Thailand | 176 | 7.6 | 6.52–8.81 | 128 | 4.9 | 4.12–5.88 | 0.7 | ▼* |
| *Western Asia* | *34* | *4.7* | *3.29–6.63* | *25* | *2.3* | *1.50–3.43* | *0.5* | ▼ |
| Lebanon | 16 | 7.0 | 3.97–11.28 | 10 | 3.2 | 1.56–5.99 | 0.5 | ▼ |
| Israel | 18 | 3.7 | 2.19–5.85 | 15 | 2.0 | 1.09–3.21 | 0.5 | ▼ |
| *Eastern Asia* | *25* | *1.3* | *0.85–1.93* | *20* | *1.1* | *0.64–1.63* | *0.8* | ▼ |
| China | 25 | 1.3 | 0.85–1.93 | 20 | 1.0 | 0.64–1.63 | 0.8 | ▼ |
| Africa | 465 | 7.9 | 7.22–8.68 | 460 | 5.3 | 4.86–5.85 | 0.7 | ▼* |
| *Sub-Saharan Africa* | *306* | *17.6* | *15.68–19.68* | *267* | *12.9* | *11.39–14.54* | *0.7* | ▼* |
| Madagascar | 27 | 162.2 | 106.89–235.98 | 30 | 182.6 | 123.16–260.60 | 1.1 | ▲ |
| Burkina Faso | 15 | 152.5 | 85.34–251.48 | 13 | 176.8 | 94.11–302.25 | 1.2 | ▲ |
| Benin | 9 | 113.7 | 51.98–215.8 | 8 | 110.3 | 47.61–217.27 | 1.0 | ▼ |
| Gambia | 6 | 46.6 | 17.10–101.45 | 20 | 60.0 | 36.63–92.61 | 1.3 | ▲ |
| United Republic of Tanzania | 104 | 66.2 | 54.08–80.19 | 65 | 34.6 | 26.68–44.07 | 0.5 | ▼* |
| Togo | 26 | 253.2 | 165.38–370.94 | 11 | 32.8 | 16.35–58.59 | 0.1 | ▼* |
| Cameroon | 15 | 28.7 | 16.08–47.39 | 13 | 28.1 | 14.95–48.00 | 1.0 | ▼ |
| Ethiopia | 31 | 27.2 | 18.51–38.67 | 21 | 18.1 | 11.21–27.69 | 0.7 | ▼ |
| Namibia | 32 | 10.7 | 7.32–15.11 | 39 | 11.3 | 8.04–15.46 | 1.1 | ▲ |
| Cabo Verde | 7 | 3.2 | 1.30–6.65 | 12 | 4.6 | 2.36–7.98 | 1.4 | ▲ |
| South Africa | 34 | 4.0 | 2.79–5.64 | 35 | 3.5 | 2.40–4.79 | 0.9 | ▼ |
| *Northern Africa* | *159* | *3.9* | *3.28–4.50* | *193* | *3.0* | *2.55–3.40* | *0.8* | ▼ |
| Morocco | 57 | 7.1 | 5.38–9.21 | 76 | 6.7 | 5.26–8.35 | 0.9 | ▼ |
| Egypt | 80 | 3.1 | 2.49–3.90 | 104 | 2.2 | 1.82–2.70 | 0.7 | ▼ |
| Tunisia | 22 | 2.9 | 1.78–4.31 | 13 | 1.8 | 0.94–3.03 | 0.6 | ▼ |
| Americas | 530 | 4.7 | 4.34–5.15 | 693 | 6.1 | 5.62–6.53 | 1.3 | ▲* |
| *Latin America* | *390* | *15.8* | *14.25–17.43* | *523* | *19.2* | *17.63–20.97* | *1.2* | ▲* |
| Colombia | 72 | 46.5 | 36.41–58.60 | 131 | 62.1 | 51.91–73.68 | 1.3 | ▲ |
| Bolivia (Plurinational State of) | 25 | 26.4 | 17.10–39.02 | 37 | 39.4 | 27.73–54.28 | 1.5 | ▲ |
| Peru | 57 | 26.2 | 19.86–33.97 | 83 | 33.7 | 26.85–41.79 | 1.3 | ▲ |
| Ecuador | 34 | 35.9 | 24.83–50.10 | 31 | 29.6 | 20.14–42.07 | 0.8 | ▼ |
| Nicaragua | 21 | 40.9 | 25.31–62.51 | 11 | 28.4 | 14.17–50.81 | 0.7 | ▼ |
| Guatemala | 14 | 28.0 | 15.30–46.97 | 14 | 24.0 | 13.14–40.34 | 0.9 | ▼ |
| Panama | 7 | 10.0 | 4.01–20.56 | 23 | 21.3 | 13.48–31.90 | 2.1 | ▲ |
| Costa Rica | 25 | 12.6 | 8.16–18.61 | 35 | 15.5 | 10.78–21.53 | 1.2 | ▲ |
| Mexico | 62 | 10.1 | 7.76–12.97 | 87 | 11.3 | 9.04–13.93 | 1.1 | ▲ |
| Brazil | 64 | 9.0 | 6.93–11.49 | 56 | 9.1 | 6.83–11.75 | 1.0 | ▲ |
| Chile | 9 | 4.2 | 1.91–7.93 | 15 | 6.2 | 3.48–10.26 | 1.5 | ▲ |

(*Continued*)

**Table 2.** Continued

| Continent/region/ country of exposure | 2014–16 | | | 2017–19 | | | Ratio[a] | Trend[b,c] |
|---|---|---|---|---|---|---|---|---|
| | Number of travel-related cases | Incidence (cases/100 000 travellers) | 95% CI | Number of travel-related cases | Incidence (cases/100 000 travellers) | 95% CI | | |
| *Caribbean* | *82* | *6.3* | *5.04–7.87* | *95* | *7.4* | *5.97–9.02* | *1.2* | ▲ |
| Cuba | 51 | 9.2 | 6.82–12.05 | 64 | 10.2 | 7.87–13.04 | 1.1 | ▲ |
| Dominican Republic | 31 | 4.2 | 2.86–5.97 | 31 | 4.7 | 3.19–6.66 | 1.1 | ▲ |
| *Northern America* | *58* | *0.8* | *0.59–1.01* | *75* | *1.0* | *0.79–1.27* | *1.3* | ▲ |
| Canada | 20 | 2.0 | 1.19–3.01 | 14 | 1.1 | 0.63–1.92 | 0.6 | ▼ |
| United States of America | 38 | 0.6 | 0.42–0.81 | 61 | 1.0 | 0.75–1.26 | 1.7 | ▲ |
| Oceania | 9 | 1.6 | 0.72–3.01 | 7 | 1.1 | 0.45–2.32 | 0.7 | ▼ |
| *Australia and New Zealand* | *9* | *1.6* | *0.72–3.01* | *7* | *1.1* | *0.45–2.32* | *0.7* | ▼ |
| Australia | 9 | 1.6 | 0.72–3.01 | 7 | 1.1 | 0.45–2.32 | 0.7 | ▼ |
| Europe | 486 | 0.2 | 0.22–0.27 | 569 | 0.2 | 0.23–0.27 | 1.0 | ▼ |
| *Southern Europe* | *351* | *0.4* | *0.39–0.48* | *395* | *0.4* | *0.35–0.43* | *1.0* | ▼ |
| Serbia | 6 | 3.2 | 1.19–7.07 | 9 | 3.3 | 1.52–6.30 | 1.0 | ▲ |
| Albania | 29 | 10.3 | 6.92–14.84 | 7 | 1.6 | 0.66–3.36 | 0.2 | ▼ * |
| Portugal | 30 | 0.8 | 0.52–1.11 | 29 | 0.6 | 0.38–0.81 | 0.7 | ▼ |
| Spain | 123 | 0.4 | 0.32–0.46 | 176 | 0.5 | 0.44–0.59 | 1.3 | ▲ |
| Croatia | 31 | 0.5 | 0.33–0.69 | 28 | 0.3 | 0.22–0.49 | 0.7 | ▼ |
| Greece | 28 | 0.3 | 0.22–0.48 | 41 | 0.3 | 0.24–0.46 | 1.0 | ▲ |
| Italy | 104 | 0.3 | 0.28–0.41 | 105 | 0.3 | 0.22–0.32 | 0.8 | ▼ |
| *Eastern Europe* | *49* | *0.2* | *0.17–0.31* | *72* | *0.3* | *0.23–0.37* | *1.5* | ▲ |
| Romania | 8 | 1.0 | 0.44–2.01 | 18 | 1.9 | 1.13–3.00 | 1.9 | ▲ |
| Bulgaria | 15 | 1.2 | 0.69–2.02 | 13 | 0.8 | 0.44–1.43 | 0.7 | ▼ |
| Poland | 12 | 0.3 | 0.14–0.47 | 20 | 0.4 | 0.22–0.57 | 1.4 | ▲ |
| Czechia | 8 | 0.1 | 0.07–0.30 | 7 | 0.1 | 0.05–0.24 | 0.8 | ▼ |
| Hungary | 6 | 0.1 | 0.02–0.14 | 14 | 0.1 | 0.07–0.23 | 2.0 | ▲ |
| *Northern Europe* | *8* | *0.1* | *0.04–0.16* | *15* | *0.2* | *0.09–0.26* | *2.0* | ▲ |
| United Kingdom of Great Britain and Northern Ireland | 8 | 0.1 | 0.04–0.16 | 15 | 0.2 | 0.09–0.26 | 2.0 | ▲ |
| *Western Europe* | *78* | *0.1* | *0.07–0.11* | *87* | *0.1* | *0.07–0.11* | *1.0* | ▼ |
| Austria | 21 | 0.1 | 0.04–0.09 | 22 | 0.0 | 0.03–0.08 | 0.8 | ▼ |
| France | 48 | 0.1 | 0.10–0.18 | 50 | 0.1 | 0.10–0.17 | 1.0 | ▶ |
| Netherlands | 9 | 0.1 | 0.03–0.13 | 15 | 0.1 | 0.05–0.14 | 1.3 | ▲ |

[a]Incidence 2017–19/Incidence 2014–16 [b]Incidence 2017–19 higher (upward trend: ▲), the same (stable trend: ▶) or lower (downward trend: ▼) than incidence in 2014–16 [c]= * indicates if the trend is statistically significant

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Franziska Hommes (Formal analysis [lead], Investigation [lead], Methodology [equal], Resources [lead], Visualization [lead], Writing—original draft [lead]), Achim Dörre (Formal analysis [supporting], Methodology [supporting], Writing—review & editing [supporting]), Susanne Behnke (Resources [supporting], Writing—review & editing [supporting]), Klaus Stark (Conceptualization [supporting], Writing—review & editing [supporting]) and Mirko Faber (Conceptualization [lead], Methodology [equal], Supervision [lead], Writing—review & editing [supporting])

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## Ethical statement

The RKI is the national public health institute and collects surveillance data on notifiable diseases according to the German Infection protection act. This study was based on anonymized surveillance data and publicly available tourism statistics published by the UNWTO. The study did not require approval from an ethics committee.

## Data availability statement

The data underlying this article will be shared in aggregated form on reasonable request to the corresponding author.

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