Travel Medicine and Infectious Disease 44 (2021) 102174

Contents lists available at ScienceDirect

Travel Medicine and Infectious Disease

journal homepage: www.elsevier.com/locate/tmaid

Vector-borne and zoonotic infections and their relationships with regional and socioeconomic statuses: An ID-IRI survey in 24 countries of Europe, Africa and Asia

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https://doi.org/10.1016/j.tmaid.2021.102174
Received 19 May 2021; Received in revised form 25 September 2021; Accepted 12 October 2021
Available online 23 October 2021

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ARTICLE INFO

Keywords:
Zoonosis
Economic status
Tick
Vector
Infection

ABSTRACT

Background: In this cross-sectional, international study, we aimed to analyze vector-borne and zoonotic infections (VBZI), which are significant global threats.
Method: VBZIs' data between May 20–28, 2018 was collected. The 24 Participatingcountries were classified as lower-middle, upper-middle, and high-income.
Results: 382 patients were included. 175(45.8%) were hospitalized, most commonly in Croatia, Egypt, and Romania($P = 0.001$). There was a significant difference between distributions of VBZIs according to geographical regions($P < 0.001$). Amebiasis, Ancylostomiasis, Blastocystosis, Cryptosporidiosis, Giardiasis, Toxoplasmosis were significantly more common in the Middle-East while Bartonellosis, Borreliosis, Cat Scratch Disease, Hantavirus syndrome, Rickettsiosis, Campylobacteriosis, Salmonellosis in Central/East/South-East Europe; Brucellosis and Echinococcosis in Central/West Asia; Campylobacteriosis, Chikungunya, Tick-borne encephalitis, Visceral Leishmaniasis, Salmonellosis, Toxoplasmosis in the North-Mediterranean; CCHF, Cutaneous Leishmaniasis, Dengue, Malaria, Taeniasis, Salmonellosis in Indian Subcontinent; Lassa Fever in West Africa. There were significant regional differences for viral hemorrhagic fevers($P < 0.001$) and tick-borne infections($P < 0.001$), and according to economic status for VBZIs($P < 0.001$). The prevalences of VBZIs were significantly higher in lower-middle income countries($P = 0.001$). The most similar regions were the Indian Subcontinent and the Middle-East, the Indian Subcontinent and the North-Mediterranean, and the Middle-East and North-Mediterranean regions.
Conclusions: Regional and socioeconomic heterogeneity still exists for VBZIs. Control and eradication of VBZIs require evidence-based surveillance data, and multidisciplinary efforts.

1. Introduction

Vector-borne and zoonotic infections (VBZI) caused by parasites and viruses in particular, have become significant public health threats globally [1] and they have serious impacts on global travel. In principal, zoonotic diseases are human infections that originate from nonhuman vertebrates and farm animals, pets, wild animals or fishesmay transmit the disease [2,3]. Vector-borne diseases are mainly zoonotic diseases transmitted to humans. Each year zoonoses account for nearly 2.5 billion cases and 2.7 million deaths worldwide, besides economic implications [1]. Thus, they exert significant pressures on economies and contribute to poverty since they disrupt animal products' production and trade. At the same time, they threaten international health security with their potential to result in global impacts. This cross-sectional, multi-center, prospective study aimed to determine the burden of VBZIs infections in a large geographical area.

2. Materials and methods

In this cross-sectional, prospective, multi-center study, the data between May 20–28, 2018 was collected. Pediatric (less than 15 years of age) group and patients with infection other than a zoonotic/vector-borne infection were excluded.

2.1. Data collection

All patients with VBZIs applied or hospitalized in participant centers were included in the survey in the study period and their data were submitted. The data was collected from well-known referral centers, which can be accepted as the representatives of the countries they are located. May 20 to May 28, 2021 period was accepted as it is both appropriate and representative.

Patient database: An online questionnaire was prepared via google forms for each enrolled patient. In each center, data were submitted by the researcher who is committed as per institutional agreement to

Table 1
Prevalence of patients diagnosed with VBZI among Outpatients and Inpatients by country.

Country	Total hospitalized pts inside the hospitals	Total pts applied to outpatient clinics	Total Hospitalized VBZI pts	Total VBZI pts applied to outpatient clinics	Prevalence of VBZI among inpatients	The letter symbols for the differences among the countries[a]	Prevalence of VBZI among outpatients	The letter symbols for the differences among the countries[a]
Albania	47	518	2	0	4.255	b	0.000	d
Bosnia and Herzegovina	545	5523	8	0	1.468	b	0.000	d
Croatia	96	592	20	22	20.833	a	3.716	b
Czech Republic	478	2480	3	14	0.628	c	0.565	c
Egypt	60	3846	12	93	20.000	a	2.418	b
France	1937	24883	6	0	0.310	c	0.000	d
India	264	1863	3	8	1.136	b	0.429	c
Iran	800	2800	13	5	1.625	b	0.179	c
Israel	1245	12555	4	1	0.321	c	0.008	d
Italy	3304	7183	10	6	0.303	c	0.084	d
Jordan	192	1541	0	3	0.000	d	0.195	c
Kazakhstan	288	406	7	9	2.431	b	2.217	b
Lebanon	253	354	0	1	0.000	d	0.282	c
Macedonia	62	65	2	0	3.226	b	0.000	d
North Cyprus Turkish Republic	44	512	2	0	4.545	b	0.000	d
Nigeria	275	133	13	3	4.727	b	2.256	b
Oman	5759	1024	3	0	0.052	d	0.000	d
Pakistan	2160	12975	11	10	0.509	c	0.077	d
Romania	435	1914	28	8	6.437	a	0.418	c
Russia	653	187	10	12	1.531	b	6.417	a
Saudi Arabia	2631	9780	5	1	0.190	c	0.010	d
Türkiye	6616	178297	14	8	0.212	c	0.004	d

Prevalence of VBZI among inpatients: (Total Hospitalized VBZI pts/Total Hospitalized pts inside the hospitals) x100.
Prevalence of VBZI among outpatients: (Total VBZI pts applied to outpatient clinics/Total pts applied to outpatient clinics) x 100.
[a] The difference between countries which have different letter is significant.

collaborate in the study.

Institutional database: An excel file was sent to participating centers to collect institutional data. The excel file included the total numbers of inpatient beds, hospitalized patients, outpatients applied to the hospital, outpatients applied to the infectious diseases department, inpatients diagnosed with VBZIs, outpatients diagnosed with VBZIs in the study week. They have provided their institutional data and the final institutional database was formed by merging of these individual datasets.

Socioeconomic distribution of the countries was classified as lower-middle (Egypt, India, Nigeria, Pakistan), upper-middle (Albania, Bosnia and Herzegovina, Iran, Jordan, Kazakhstan, Lebanon, North Macedonia, Russia, Türkiye), and high-income countries (Croatia, Czech Republic, France, Israel, Italy, Cyprus, Oman, Romania, Saudi Arabia) [4].

2.2. Geographical distribution

a) Central/East/South-East Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, North Macedonia, Romania, Russia)
b) Central/West Asia (Iran, Kazakhstan)
c) Indian Subcontinent (India, Pakistan)
d) Middle-East (Egypt, Israel, Jordan, Lebanon, Oman, Saudi Arabia)
e) North-Mediterranean (France, Italy, Cyprus, Türkiye), West-Africa (Nigeria).

2.3. Definitions

Zoonosis is an infectious disease of humans that originates from vertebrate animals.

Vector-borne infections are human illnesses transmitted by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails, lice, among others.

Viral hemorrhagic fevers (VHF) were Hantavirus, Dengue virus, Lassa fever, and Crimean-Congo hemorrhagic fever (CCHF) infections.

Tick-borne infections: Tick-borne infections in this survey comprised those with the main route of transmission is through ticks. Anaplasmosis, Borreliosis, CCHF, Rickettsiosis, Tick-borne encephalitis, and Typhus were in this category.

2.3.1. Statistical analysis

The distribution of VBZIs by the geographical regions and economic statuses were analyzed with the Fisher-Freeman-Halton test. The Pearson-Chi square test was used to compare geographical regions and economic statuses for VHFs and tick-borne infections. The significant results were obtained from these tests were investigated with Post-Hoc Hochberg test. In the analysis, VBZIs richness by the geographical regions, four different Alpha Diversity indexes were calculated. Similarities in the geographical distributions of VBZIs were analyzed with Chao-Sorensen Estimated Abundance based similarity index. $P < 0.05$ was accepted as statistically significant. SPSS (ver.23) and EstimateS (Trial Version 9.1.0) programs were used in all calculations.

3. Results

In this study, 382 patients were included. Of them, 219 (57.3%) were males. The mean age was 41.44 ± 17.28 (1–87) years. 175 (%45.8) patients were hospitalized. The most common presentations were febrile illness (n = 154, 40.3%), diarrheal illness (n = 103, 27%), osteoarticular involvement (n = 36, 9.4%), hepatic involvement (n = 35, 9.2%), pneumonia (n = 26, 6.8%), renal involvement (n = 22, 5.8%), skin lesions (n = 20, 5.2%), ocular lesions (n = 18, 4.7%), lymphadenitis (n = 10, 2.6%), CNS involvement (n = 10, 2.6%), bleeding (n = 5, 1.3%), and others (n = 13, 3.4%).

3.1. Geographical VBZI distributions

VBZIs were hospitalized most commonly in Croatia, Egypt, and Romania more than in other countries (P = 0.001). Albania, Bosnia and

Table 2
Distributions of vector borne or zoonotic disease in accordance with the geographical regions[a].

	Central/East/South-East Europe		Central/West Asia		Indian Subcontinent		Middle East		North Mediterranean		West Africa		Total
	n	%	n	%	n	%	n	%	n	%	n	%	
Amebiasis	0	0.0	0	0.0	0	0.0	19	15.3[a]	0	0.0	0	0.0	19
Anaplasmosis	1	0.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
Ancylostomiasis	0	0.0	0	0.0	0	0.0	5	4.0[a]	0	0.0	0	0.0	5
Bartonellosis	4	3.1[a]	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4
Blastocystosis	0	0.0	0	0.0	0	0.0	7	5.6[a]	0	0.0	0	0.0	7
Borreliosis	32	24.6[a]	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	32
Brucellosis	3	2.3[d]	27	81.8[a]	3	9.4[c]	8	6.5[c]	12	25.5[b]	0	0.0[d]	53
Campylobacteriosis	6	4.6[a]	0	0.0	0	0.0	2	1.6	2	4.3[a]	0	0.0	10
Cat scratch disease	6	4.6[a]	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6
CCHF	0	0.0	0	0.0	3	9.4[a]	0	0.0	1	2.1[b]	0	0.0	4
Chikungunya infection	0	0.0	0	0.0	0	0.0	0	0.0	2	4.3[a]	0	0.0	2
Cryptosporidiosis	0	0.0	0	0.0	1	3.1[b]	15	12.1[a]	3	6.4[b]	0	0.0	19
Cutaneous Leishmaniasis	0	0.0	0	0.0	2	6.3[a]	1	0.8	0	0.0	0	0.0	3
Dengue	3	2.3[a]	0	0.0	2	6.3[a]	1	0.8	1	2.1[a]	0	0.0	7
Echinococcosis	7	5.4[b]	6	18.2[a]	1	3.1[b]	1	0.8[b]	2	4.3[b]	0	0.0[b]	17
ETEC	0	0.0	0	0.0	0	0.0	0	0.0	1	2.1	0	0.0	1
Filariasis	0	0.0	0	0.0	0	0.0	3	2.4	0	0.0	0	0.0	3
Giardiasis	0	0.0	0	0.0	2	6.3[b]	28	22.6[a]	1	2.1[b]	0	0.0	31
Hantavirus syndrome	14	10.8[a]	0	0.0	0	0.0	0	0.0	2	4.3[b]	0	0.0	16
Lassa fever	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	16	100.0[a]	16
Leptospirosis	4	3.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	4
Listeriosis	0	0.0	0	0.0	0	0.0	0	0.0	1	2.1	0	0.0	1
Malaria	3	2.3[c]	0	0.0	9	28.1[a]	3	2.4[c]	5	10.6[b]	0	0.0	20
Rickettsiosis	24	18.5[a]	0	0.0	0	0.0	3	2.4[b]	1	2.1[b]	0	0.0	28
Salmonellosis	9	6.9[a]	0	0.0	3	9.4[a]	1	0.8	2	4.3[a]	0	0.0	14
Scabies	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0	1
Taeniasis	0	0.0	0	0.0	3	9.4[a]	3	2.4[b]	0	0.0	0	0.0	6
Tick-borne encephalitis	1	0.8	0	0.0	0	0.0	0	0.0	2	4.3[a]	0	0.0	3
Toscana virus	0	0.0	0	0.0	0	0.0	0	0.0	1	2.1	0	0.0	1
Toxocariasis	4	3.1	0	0.0	0	0.0	4	3.2	0	0.0	0	0.0	8
Toxoplasmosis	6	4.6[b]	0	0.0	1	3.1[b]	18	14.5[a]	5	10.6[a]	0	0.0	30
Tularemia (oropharyngeal)	0	0.0	0	0.0	0	0.0	0	0.0	1	2.1	0	0.0	1
Typhus	0	0.0	0	0.0	2	6.3[a]	0	0.0	0	0.0	0	0.0	2
Viral Hepatitis-E	1	0.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1
Visceral Leishmaniasis	0	0.0	0	0.0	0	0.0	0	0.0	2	4.3[a]	0	0.0	2
West Nile fever	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0	1
Yersiniosis	2	1.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2
Total	**130**		**33**		**32**		**124**		**47**		**16**		**382**
Viral hemorrhagic fevers	17	13.1[b]	0	0.0[a]	5	15.6[b]	1	0.8[a]	4	8.5[b]	16	100.0[c]	46
Tick borne infections	58	44.6[d]	0	0.0[a]	5	15.6[c]	3	2.4[b]	4	8.5[bc]	0	0.0[a]	70

For a particular disease, significant differences between economic status were shown with different letters, which were placed byside of proportions.
[a] Fisher-Freeman-Halton exact test, Post-Hoc Hochberg test.

Herzegovina, Cyprus, India, Iran, Kazakhstan, North Macedonia, Nigeria, and Russia followed these countries. The lowest rates were observed in Jordan, Lebanon and Oman (Table 1). The distribution of VBZIs in accordance with the countries are presented in Table 2

The distribution of VBZIs in accordance with the countries are presented in Table 2.

There was a significant difference between geographical distributions of VBZIs ($P < 0.001$) (Table 3). Amebiasis, Ancylostomiasis, Blastocystosis, Cryptosporidiosis, Giardiasis, and Toxoplasmosis were significantly more common in the Middle-East while Bartonellosis, Borreliosis, Cat Scratch Disease, Hantavirus syndrome, Rickettsiosis, Campylobacteriosis, and Salmonellosis in Central/East/South-East Europe; Brucellosis and Echinococcosis in Central/West Asia; Campylobacteriosis, Chikungunya, Tick-borne encephalitis, Visceral Leishmaniasis, Salmonellosis, Toxoplasmosis in the North Mediterranean; CCHF, Cutaneous Leishmaniasis, Dengue, Malaria, Taeniasis, Salmonellosis in Indian Subcontinent; Lassa Fever in West-Africa.

There were significant differences for VHFs ($P < 0.001$) and tick-borne infections ($P < 0.001$) by the geographical variations. Thus, VHFs were common in West-Africa. On the other hand, tick-borne infections were common in Central/East/South-East Europe followed by Indian Subcontinent, and the North-Mediterranean regions.

3.2. Economic status and VBZIs

When the economic status was considered, there were significant differences between the distributions of VBZIs ($P < 0.001$) (Table 4). Amebiasis, Cryptosporidiosis, Echinococcosis, Giardiasis, Lassa Fever, and Taeniasis were more common in lower-middle Brucellosis, Malaria, Salmonellosis, and Toxocariasis in upper-middle-income countries, and Bartonellosis, Blastocystosis, Borreliosis, Campylobacteriosis, Cat-scratch disease, Hantavirus syndrome, and Rickettsiosis in high-income countries. VHFs did not have a difference by the economic status ($P = 0.200$). However, Tick-borne infections' distribution was the lowest in lower-middle-income, moderate in upper-middle-income, and highest in high-income countries ($P < 0.001$). The prevalence of hospitalized VBZI was significantly higher in lower-middle-income countries than in richer countries ($P = 0.001$). There was no difference in the prevalence rates in upper-middle and high-income countries. Accordingly, the prevalence of VBZIs applied to hospitals as outpatients was the highest in lower-middle-income countries followed by high-income countries. The lowest prevalence rate for outpatients was observed in upper-middle-income countries ($P = 0.001$).

3.3. The assessment of VBZIs richness

Four different Alpha Diversity indexes were calculated for assessing

Table 3
Economic status of the countries and distributions of vector borne and zoonotic infections.

VECTORBORNE OR ZOONOTIC DISEASES	High-Income		Lower-Middle Income		Upper-Middle Income		Total
	n	%	n	%	n	%	n
Amebiasis	0	0.0[a]	19	12.4[b]	0	0.0[a]	19
Anaplasmosis	1	0.7	0	0.0	0	0.0	1
Ancylostomiasis	0	0.0	5	3.3	0	0.0	5
Bartonellosis	4	3.0[a]	0	0.0[b]	0	0.0[b]	4
Blastocystosis	0	0.0[a]	7	4.6[b]	0	0.0[a]	7
Borreliosis	23	17.0[a]	0	0.0[c]	9	9.6[b]	32
Brucellosis	6	4.4[a]	3	2.0[a]	44	46.8[b]	53
Campylobacteriosis	8	5.9[a]	0	0.0[b]	2	2.1[ab]	10
Cat scratch disease	4	3.0[a]	0	0.0[b]	2	2.1[ab]	6
CCHF	0	0.0	3	2.0	1	1.1	4
Chikungunya infection	2	1.5	0	0.0	0	0.0	2
Cryptosporidiosis	0	0.0[a]	16	10.5[b]	3	3.2[c]	19
Cutaneous Leishmaniasis	0	0.0	3	2.0	0	0.0	3
Dengue	3	2.2	2	1.3	2	2.1	7
Echinococcosis	7	5.2[a]	2	1.3[b]	8	8.5[a]	17
ETEC	1	0.7	0	0.0	0	0.0	1
Filariasis	0	0.0	3	2.0	0	0.0	3
Giardiasis	1	0.7[a]	30	19.6[b]	0	0.0[a]	31
Hantavirus syndrome	13	9.6[a]	0	0.0[c]	3	3.2[b]	16
Lassa fever	0	0.0[a]	16	10.5[b]	0	0.0[a]	16
Leptospirosis	2	1.5	0	0.0	2	2.1	4
Listeriosis	1	0.7	0	0.0	0	0.0	1
Malaria	10	7.4[a]	9	5.9[a]	1	1.1[b]	20
Rickettsiosis	23	17.0[a]	0	0.0[c]	5	5.3[b]	28
Salmonellosis	3	2.2[a]	3	2.0[a]	9	9.6[b]	14
Scabies	0	0.0	1	0.7	0	0.0	1
Taeniasis	0	0.0[a]	6	3.9[b]	0	0.0[a]	6
Tick-borne encephalitis	3	2.2	0	0.0	0	0.0	3
Toscana virus	1	0.7	0	0.0	0	0.0	1
Toxocariasis	4	3.0[a]	4	2.6[a]	0	0.0[b]	8
Toxoplasmosis	10	7.4	19	12.4	1	1.1	30
Tularemia (oropharyngeal)	0	0.0	0	0.0	1	1.1	1
Typhus	0	0.0	2	1.3	0	0.0	2
Viral Hepatitis-E	1	0.7	0	0.0	0	0.0	1
Visceral Leishmaniasis	2	1.5	0	0.0	0	0.0	2
West Nile fever	1	0.7	0	0.0	0	0.0	1
Yersiniosis	1	0.7	0	0.0	1	1.1	2
TOTAL	135		153		94		382
Viral hemorrhagic fevers	16	11.9	21	13.7	6	6.4	46
Tick borne infections	50	37.0[c]	5	3.3[a]	15	16.0[b]	70
VbZI prevalence, inpatients	39	**1.41** [a]	56	**0.60** [b]	81	**0.51** [b]	176
Total Inpatients	2759		9456		15929		28144
VbZI prevalence, outpatients	114	**0.61** [a]	38	**0.02** [c]	52	**0.10** [b]	204
Total Outpatients	18817		189691		60923		269431

a: Fisher-Freeman-Halton exact test. Post-Hoc Hochberg test.
For a particular disease, significant differences between economic status were shown with different letters, which were placed byside of proportions.

Table 4
Alpha diversity (richness, or total number of different diseases) for vector-borne and zoonotic infectious diseases.

Geographic Region	ACE		Alpha		Shannon		Simpson Invers	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Central, East, South-East Europe	27.05	2.02	11.20	2.23	2.78	0.09	13.17	1.42
Central/West Asia	32.92	3.47	10.68	1.52	2.94	0.06	14.71	1.01
Indian Subcontinent	37.70	4.10	10.62	1.28	3.00	0.04	15.44	0.76
Middle East	41.09	4.14	10.63	1.15	3.04	0.03	15.79	0.55
North Mediterranean	42.81	3.62	10.52	1.05	3.06	0.02	15.95	0.34
West Africa	45.08	0	10.49	0.99	3.07	0	16.11	0

VBZIs richness. (Table 5). When the interregional differences were compared according to ACE, Shannon, Simpson Invers indexes, the VBZI richness in the Middle-East and the North-Mediterranean were higher. These coefficients being higher in West-Africa were because the disease was observed only in that region, and no other VBZI was recorded. The VBZI richness was lower in Central/West Asia and Central/East/South-East Europe.

3.4. Regional similarities

When the interregional similarities were compared according to these scales, the results presented in Table 6 were obtained. Chao-Sorensen Estimated Abundance based similarity index was calculated to evaluate the similarities in VBZIs distributions among the geographical regions. The most similar regions for VBZIs distributions were Indian Subcontinent and the Middle-East, Indian Subcontinent and the North Mediterranean, the Middle-East and the North-Mediterranean

Table 5
The similarities between the geographical regions according to VBZIs distribution.

First Region	Second Region	Sobs[a]			Chao-Sorensen Estimated Abundance based similarity index	
		First region	Second region	Shared Diseases Observed	Coefficient	SD
Central, East, South-East Europe	Central/West Asia	18	2	2	0.143	0.093
Central, East, South-East Europe	Indian Subcontinent	18	12	6	0.380	0.154
Central, East, South-East Europe	Middle East	18	19	9	0.453	0.159
Central, East, South-East Europe	North Mediterranean	18	19	10	0.680	0.143
Central, East, South-East Europe	West Africa	18	1	0	0	0
Central/West Asia	Indian Subcontinent	2	12	2	0.222	0.162
Central/West Asia	Middle East	2	19	2	0.135	0.104
Central/West Asia	North Mediterranean	2	19	2	0.459	0.239
Central/West Asia	West Africa	2	1	0	0	0
Indian Subcontinent	Middle East	12	19	10	0.848	0.146
Indian Subcontinent	North Mediterranean	12	19	9	0.843	0.128
Indian Subcontinent	West Africa	12	1	0	0	0
Middle East	North Mediterranean	19	19	10	0.823	0.168
Middle East	West Africa	19	1	0	0	0
North Mediterranean	West Africa	19	1	0	0	0

[a] **Sobs:** Number of observed diseases.

regions. On the other hand, West-Africa was entirely dissimilar to Central/East/South-East Europe, Central/West Asia, Indian Subcontinent, the Middle-East, and the North-Mediterranean regions. Besides, the similarity of Central/West Asia to other regions was low.

4. Discussion

In the pre-antibiotic era community-acquired bacterial infections were the causes of significant mortality and morbidity [5]. Unfortunately, VBZIs continue to be a significant public health threat globally in the 21st century. Our study disclosed peculiar characteristics of VBZIs in a wide geographical area. Primarily, Brucellosis, as the great imitator [6], was the top leading VBZI worldwide, and the prevalence rates of VBZIs differed greatly. Basically, the prevalences of either hospitalized or outpatient VBZIs were significantly higher in LMI countries compared to richer ones. Among hospitalized patients, it was significantly higher in Croatia, Egypt, Romania, and the prevalence of VBZIs in outpatient clinics was significantly higher in Russia. Although the epidemiology is known to differ worldwide, the most similar regions for VBZIs were the Middle-East, the Indian Subcontinent, and the North-Mediterranean regions. Western Africa had quite different characteristics, mostly due to VHFs, and accordingly, the Central/West Asia had its peculiar features due to VBZIs likely to be related to husbandry. Definitively, economic status affected the epidemiology of VBZIs greatly.

When the geographical differences were focused in this study, intestinal parasites and toxoplasmosis were the most common in the Middle-East. Besides, it has long been believed that intestinal infections have a strong relationship between poverty, an unhygienic environment, and the intestinal parasitic diseases affect the children at most in particular [7,8]. This in this survey, too. Approximately 65 out 400 million people of the Middle-East and North Africa region live on less than US$2 per day [9], a fact clarifying the current situation.

Ticks are a foremost group of arthropod vectors, depicted by the variety of pathogens they spread and their impact on human and animal health, and by their socioeconomic implications particularly in the Southern Hemisphere countries [10,11]. We have shown that tick-born infections like Bartonellosis, Rickettsiosis, Borreliosis, and Hantavirus infections do not spare richer regions, but rather they are more common in HI countries. Accordingly, ticks are plentiful in woodlands all across Europe from early spring to late autumn [12]. Consequently, there are many papers in the literature with vector/tick-borne infections in Europe [13,14]. Hence, this subgroup of VBZIs were detected most commonly in Central/East/South-East Europe most probably due to the region's habitat. Basically, the risk of tick-borne infections can be reduced by avoiding tick bites and removing ticks from the body by increasing awareness in the Central/East/South-East European community.

Another inference of this survey was that livestock-related VBZIs like Brucellosis and Echinococcosis were more commonly seen in Central/West Asia. Although cumulative data is lacking for Echinococcosis [15], Central/West Asia was reported to be second priority geographic locale according to the 2011 report of World Health Organization [16]. Thus, seemingly a shift took place in the last decade, and this region is an important focus for these infections according to our data. On the other hand, Brucellosis has long been known as a public health problem in the region [17,18]. Hence, rigorously enforced precautions are needed to manufacture safe meat and dairy products in Central/West Asia.

In this study, we have confirmed that tropical VBZIs like Leishmaniasis, Dengue, Malaria, Taeniasis were observed more commonly in the Indian Subcontinent. The prevalence of vector and waterborne zoonoses are likely to increase due to the effects of global warming in India. Recently, VBZIs have been recorded as a serious public health problem in the Indian subcontinent and occur in epidemic forms annually. New reservoir areas of cutaneous Leishmaniosis in South India have been recognized. These are hypothesized to be due to climate change. Similarly, climate changehas long been implicated as a major cause of increased water and foodborne illnesses, and increased risk of transmission for airborne zoonoses [19–22].

VHFs refer to a group of infections produced by several distinct viruses causing multisystemic disease. Typically, overall vascular system is impaired, accompanied by bleeding [23]. In this study, VHFs, particularly Lassa Fever, were the commonest in West-Africa followed by other VHFs in Central/East/South-East Europe, Indian Subcontinent, and North-Mediterranean regions [24,25]. Interestingly, their frequency does not correlate to the economic status of the countries.

There are several limitations in our study. The prevalence rates may be directly interrelated to many factors including seasonal variations or local outbreaks of VBZIs for each of the countries involved. Furthermore, VBZI patients may have triaged to some of the participating hospitals with the resultant high prevalence rates in the participating countries. In short, we stayed descriptive and provided the prevalence rates solely.

In conclusion, although VBZIs affect developing countries in principle, they compromise industrialized countries mostly probably due to travel, migration, and climate change among other multiple involved factors. Both the geographical differences and the economic status affected the distribution of VBZIs worldwide. Obvious regional and socioeconomic heterogeneity exists for VBZIs in Europe, Africa, and Asia which will directly affect global travel. The control and eradication of VBZIs require clinical and epidemiological suspicion supported by evidence-based surveillance data, combined efforts of veterinary

Table 6
Distribution of VBZIs in accordance with the countries.

	Amebiasis	*Anaplasmosis*	*Ancylostomiasis*	*Bartonellosis*	*Blastocystosis*	*Borreliosis*	*Brucellosis*	*Campylobacteriosis*	*Catscratchdisease*	*CCHF*	*Chikungunyainfection*	*Cryptosporidiasis*	*CutaneousLeishmaniasis*	*Dengue*	*Echinococcosis*	*ETEC*	*Filariasis*	*Giardiasis*	*Hantavirussyndrome*	*Lassafever*	*Leptospirosis*	*Listeriosis*	*Malaria*	*Rickettsiosis*	*Salmonellosis*	*Scabies*	*Taeniasis*	*Tick − borneencephalitis*	*Toscanavirus*	*Toxocariasis*	*Toxoplasmosis*	*Tularemia(oropharyngeal)*	*Typhus*	*ViralhepatitisE*	*VisceralLeishmaniasis*	*WestNilefever*	*Yersiniosis*
Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BiH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Croatia	0	1	0	4	0	8	0	4	4	0	0	0	0	1	1	0	0	0	11	0	0	0	2	2	1	0	0	1	0	0	2	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	12	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Egypt	19	0	5	0	7	0	0	0	0	0	0	15	1	0	1	0	3	28	0	0	0	0	0	0	0	1	3	0	0	4	18	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	2	0	0	0	0
Iran	0	0	0	0	0	0	12	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Israel	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0
Italy	0	0	0	0	0	0	1	0	0	0	2	0	0	1	0	1	0	0	0	0	0	1	3	1	0	0	0	0	1	0	4	0	0	0	2	0	0
Jordan	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kazakhstan	0	0	0	0	0	0	15	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lebanon	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macedonia	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Cyprus TR	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oman	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pakistan	0	0	0	0	0	0	3	0	0	3	0	1	2	1	0	0	0	2	0	0	0	0	5	0	0	0	3	0	0	0	1	0	0	0	0	0	0
Romania	0	0	0	0	0	3	0	0	0	0	0	0	0	0	6	0	0	0	0	0	1	0	0	17	1	0	0	0	0	4	3	0	0	0	0	0	1
Russia	0	0	0	0	0	7	3	0	2	0	0	0	0	2	0	0	0	0	2	0	0	0	1	1	3	0	0	0	0	0	0	0	0	0	0	0	1
Saudi Arabia	0	0	0	0	0	0	2	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Türkiye	0	0	0	0	0	0	10	2	0	1	0	3	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	0

North Cyprus TR: North Cyprus Turkish Republic, BiH: Bosnia and Herzegovina.

medicine, and the prevention strategies including immunization and other counter measures.

Author contribution

Fatma Nurhayat Saydam and Hakan Erdem designed the survey, analyzed the data and wrote the paper. Alfonso J. Rodriguez-Morales contributed writing. Handan Ankarali performed the statistical analyses. All other authors prospectively produced and submitted data. Finally, they have reviewed the paper and provided suggestions in revising it.

Acknowledgements

No funding was received for this study.
We would like to thank Prof. Daniel R. Lucey for editing the paper.

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