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Coronavirus Pandemic

Significantly correlation between tourism and COVID-19: evidence from 178 countries and territories

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Abstract

Introduction: The high development of tourism is considered a factor that facilitates the global spread of infectious diseases. The association between tourism and the epidemic of coronavirus diseases 2019 (COVID-19) remains unclear.

Methodology: We retrieved the data of COVID-19 in 178 countries/territories from the Center for Systems Science and Engineering at Johns Hopkins University. Data on tourism indicators were collected from the World Tourism Organization. We used Spearman's correlation analysis to explore the association between tourism and the epidemic of COVID-19.

Results: We find that international tourism expenditure, international tourism receipts, international tourist arrivals, and international tourism exports were significantly correlated with the total number of cases (r_s=0.86, r_s=0.79, r_s=0.80, r_s=0.81, respectively), the daily growth of cases of COVID-19 (r_s=0.84, r_s=0.76, r_s=0.78, r_s=0.78, respectively), and the number of cases (per million persons) (r_s=0.52, r_s=0.53, r_s=0.36, r_s=0.53, respectively) ($p < 0.0001$ for all), especially in places with high-income. Tourism as percentage of exports was slightly associated with the total number of cases and the daily growth of cases (r_s=-0.33, r_s=-0.33) ($p < 0.0001$ for both).

Conclusions: The clinical and public health care providers must realize the potential for the transmission of infections across regions and put more effort to prevent and respond to future infections.

Key words: Tourism; COVID-19; travel; infectious diseases.

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Introduction

The outbreak and further spread of infectious diseases can cause public health emergencies, and even threaten human life [1-3]. For a long time, human migration has been considered as an important factor in the spread of new and reemerging infectious diseases, and tourism accounts for almost 55% of the total movement and migration activities [4,5]. In the current era, a fast means of transport, such as airplanes allows people to get anywhere quickly, in a period of time shorter than the incubation period of many infectious diseases, and thus play a prominent role in the spread of infections [6]. In fact, a person infected with a zoonotic virus, for example, traveling, can arrive in another part of the world in less than 24 hours and transmit it to those with whom he comes in contact [7]. In 2019, the number of international tourist arrivals was 1461 million, with an average annual growth of 5.1% over the past ten years [4]. In the past several years, we have observed the spread of various infectious diseases between countries and continents through travel, such as the severe acute respiratory syndrome (SARS) in 2002, the influenza H1N1 in 2009, and Middle Eastern Respiratory Syndrome (MERS) in 2012 [1-3]

In late December 2019, the outbreak of newly detected coronavirus diseases 2019 (COVID-19) has rapidly escalated into a global pandemic [8]. As of 30 September 2020, more than 3,300,000 patients had been confirmed as COVID-19, with the number of deaths exceeding 1,000,000 in 185 countries/ territories [9]. Several factors that contribute to the spread of COVID-19 have already been well described, including the temperature, humidity, and climate indicators [10-12]. However, the association between tourism development and the epidemic of COVID-19 has not been well examined. In the current research, we aimed to

investigate the correlation between the development of tourism worldwide and the epidemic characteristics of COVID-19.

Methodology

Data Sources

We obtained the daily number of COVID-19 cases from the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU) and the National Health Commission of the People's Republic of China between 2020/1/22 to 2020/4/17 on April 20, 2020 [9,13]. In addition, we collected data on the world population, as of 1 July 2020 (estimated) from the Population Division Department of Economic and Social Affairs, United Nations, to calculate the number of cases (per million) for further studies [14].

To investigate the correlation between tourism and the epidemic of COVID-19 in various countries and territories, we collected the tourism data from the World Tourism Organization (UNWTO) on 20 April 2020 [15]. Tourism indicators provided by the UNWTO, including international tourism expenditure (USD billion) (ITED), international tourism receipts (USD billion) (ITR), international tourist arrivals (million) (ITA), international tourism exports (USD billion) (ITEP), and tourism as percentage of exports (TAOE) of 2018 were included. However, places affected by COVID-19, lack of tourism data, were excluded in current research (Diamond Princess, Kosovo, Western Sahara, West Bank and Gaza, South Sudan, Yemen, and MS Zaandam). Finally, 178 countries/territories were included in the current work. According to UNWTO, we divided the countries/territories into five groups: Europe (47 countries/territories), Africa (46 countries/territories), Asia and Oceania (31 countries/territories), the Americas (35 countries/territories), and the Middle East (19 countries/territories) to further investigate the correlation between tourism and the epidemic of COVID-19 in various regions. Since only four countries in Oceania (Fiji, Papua New Guinea, New Zealand, and Australia) were included in the current study and no data from the Pacific has been observed, we classified these four countries into Asia for further analysis. According to The World Bank [16], we divided the 178 countries/territories into the high-income countries/territories (Gross National Income per capita (GNIPC) of $12,376 or more in 2018), and the non-high-income countries/territories (rest of these places) to explore the relationship between tourism and the epidemic of COVID-19 in regions with different economies. In addition, ethical approval for our study was granted by The Committee on Medical Ethics of The First Affiliated Hospital of Anhui Medical University (Reference number: Quick-PJ2021-09-19). Since all data used in the current study were available online, and no individual patient was involved, it could be confirmed that we have obtained all the written informed consent.

Dynamic series analysis

Using dynamic series analysis, we described the dynamic change of the number of COVID-19 cases in 178 countries/territories. There are several statistical indicators contained in this dynamic analysis: the day by day growth, the daily development and increment rate, the link-relative and fixed base rate. The development rate of the fixed base is defined to describe the overall development direction and speed of the case numbers by comparing the number on a certain day with the baseline. While the development rate of link-relative is defined to describe the day-by-day growth rate of the case numbers by comparing a certain day's case number and the previous day's case number. Additionally, by decreasing the development rate by 100%, we get the increase rate. In the current research, the average day by day growth of cases (daily growth of cases) and the average increase rate of cases (link-relative) were calculated to investigate their correlation with the tourism indicators in 178 countries/territories (Supplementary Table 1).

Statistical analysis

We applied a statistical analysis to examine the correlation between tourism indicators and the epidemic characteristics of COVID-19 using software SPSS version 23.0. Because the data were not normally distributed, we used the Spearman correlation in current research to demonstrate the correlation between variables. Since each tourism variable was compared with four parameters of the COVID-19 epidemic, the Bonferroni method was implemented to control the Type I error for multiple comparisons, and the statistical significance was set as $p < 0.0125$ (0.05/4). The software ArcGIS 10.6 was applied to visualize our results.

Ethics statement

Ethical approval for our study was granted by The Committee on Medical Ethics of The First Affiliated Hospital of Anhui Medical University (Reference number: Quick-PJ2021-09-19). Since all the data used in the current study was available online, and no

individual patient was involved, it could be confirmed we have obtained all the written informed consent.

Results

Correlations between epidemic characteristics of COVID-19 and the tourism indicators in 178 countries/territories

Table 1 shows that the total number of cases was strongly positively correlated with ITED, ITR, ITA, and ITEP (r_s = 0.86, r_s = 0.79, r_s = 0.80, r_s = 0.81, respectively) ($p < 0.0001$ for all). Similar results were also found between the daily growth of cases and ITED, ITR, ITA and ITEP (r_s = 0.84, r_s = 0.76, r_s = 0.78, r_s = 0.78, respectively) ($p < 0.0001$ for all). There were strong but relatively slighter positive correlations between the number of cases (per million persons) and the tourism indicators, with the correlation coefficients of 0.519 (for ITED), 0.525 (for ITR), 0.360 (for ITA), and 0.528 (for ITEP) ($p < 0.0001$ for all). While no correlation was observed between the average increase rate and ITR, ITA, ITEP ($p > 0.0125$ for all). Interestingly, for the association between the total number of cases and the daily growth of cases with TAOE, slightly negative correlations were discovered (r_s=-0.33, r_s = -0.33, respectively) ($p < 0.0001$ for both). No correlations were discovered among the other variables ($p > 0.0125$ for all).

Correlations between epidemic characteristics of COVID-19 and the tourism indicators in various regions/continents

Supplementary Table 2 lists the correlations between the epidemic characteristics of COVID-19 and the tourism indicators in Europe, Africa, Asia and Oceania, Americas, and the Middle East. In Europe, we observed a positive correlation between ITED, ITR, ITA, ITEP and the total number of confirmed cases (r_s=0.88, r_s = 0.77, r_s = 0.75, r_s = 0.82, respectively), as well as the daily growth of cases (r_s = 0.88, r_s = 0.77, r_s = 0.75, r_s = 0.82, respectively) ($p < 0.0001$ for all). Besides, the number of cases (per million persons) was relatively slimmer positive correlated with tourism, with the correlation coefficients as 0.46 for ITED (p = 0.003), 0.48 for ITR (p = 0.002), and 0.49 for ITEP (p = 0.001). In comparison, there are no correlations between TAOE and all the epidemic characteristics of COVID-19 ($p > 0.0125$ for all).

In Africa, we noticed slightly positive correlations between the total number of cases, the daily growth of cases and ITED (r_s = 0.54, p = 0.001; r_s = 0.52, p = 0.002, respectively), ITR (r_s = 0.50, p = 0.005; r_s = 0.46, p = 0.011, respectively), ITEP (r_s = 0.49, p = 0.006; r_s = 0.45, p = 0.012, respectively). While no correlations exist among ITA, TAOE, and the total number of cases, the daily growth of cases; among the number of cases (per million persons), the average increase rate, and all the tourism indicators ($p > 0.0125$ for all).

In Asia and Oceania, we discovered similar results compared to those in Europe. There were strong correlations between the total number of cases, the daily growth of cases, and ITED (r_s = 0.83, r_s = 0.63, respectively, $p < 0.0001$ for both), ITR (r_s = 0.69, $p < 0.0001$; r_s = 0.51, p = 0.002, respectively), ITA (r_s = 0.84, r_s = 0.662, respectively, $p < 0.0001$ for both), ITEP (r_s = 0.71, $p < 0.0001$; r_s = 0.54, p = 0.001, respectively). Also, the number of cases (per million persons) was positively correlated with ITED (r_s = 0.47, p = 0.005). Besides, we found a negative correlation between TAOE and the daily growth of cases, with the coefficients as -0.46 (p = 0.008). No correlations between TAOE and other characteristics of the COVID-19 epidemic exist ($p > 0.0125$ for all)

In Americas, we discovered the total number of cases, the average increase rate and the daily growth of cases were significantly correlated with most of the tourism indicators, including ITED (r_s = 0.91, $p < 0.0001$; r_s = 0.58, $p < 0.001$; r_s = 0.91, $p < 0.0001$, respectively), ITR (r_s = 0.82, $p < 0.0001$; r_s = 0.50, p = 0.003; r_s = 0.81, $p < 0.0001$, respectively), ITA (r_s = 0.89, $p < 0.0001$; r_s = 0.56, p = 0.001; r_s = 0.88, $p <$

Table 1. Correlation between epidemic characteristics of COVID-19 and the tourism indicators in 178 countries/territories.

Epidemic characteristics of COVID-19		Tourism indicators				
		ITED	ITR	ITA	ITEP	TAOE
Total number of cases	r_s	0.86	0.79	0.80	0.81	-0.33
	p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Number of cases (per million persons)	r_s	0.52	0.53	0.36	0.53	-0.01
	p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.926
Average increase rate	r_s	0.20	0.11	0.10	0.13	-0.08
	p	0.015	0.179	0.250	0.100	0.328
Daily growth of cases	r_s	0.84	0.76	0.78	0.78	-0.33
	p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

COVID-19: coronavirus diseases 2019 (COVID-19); ITED: International tourism expenditure (USD billion); ITR: International tourism receipts (USD billion); ITA: International tourist arrivals (million); ITEP: International tourism exports (USD billion); TAOE:Tourism as % of Exports.

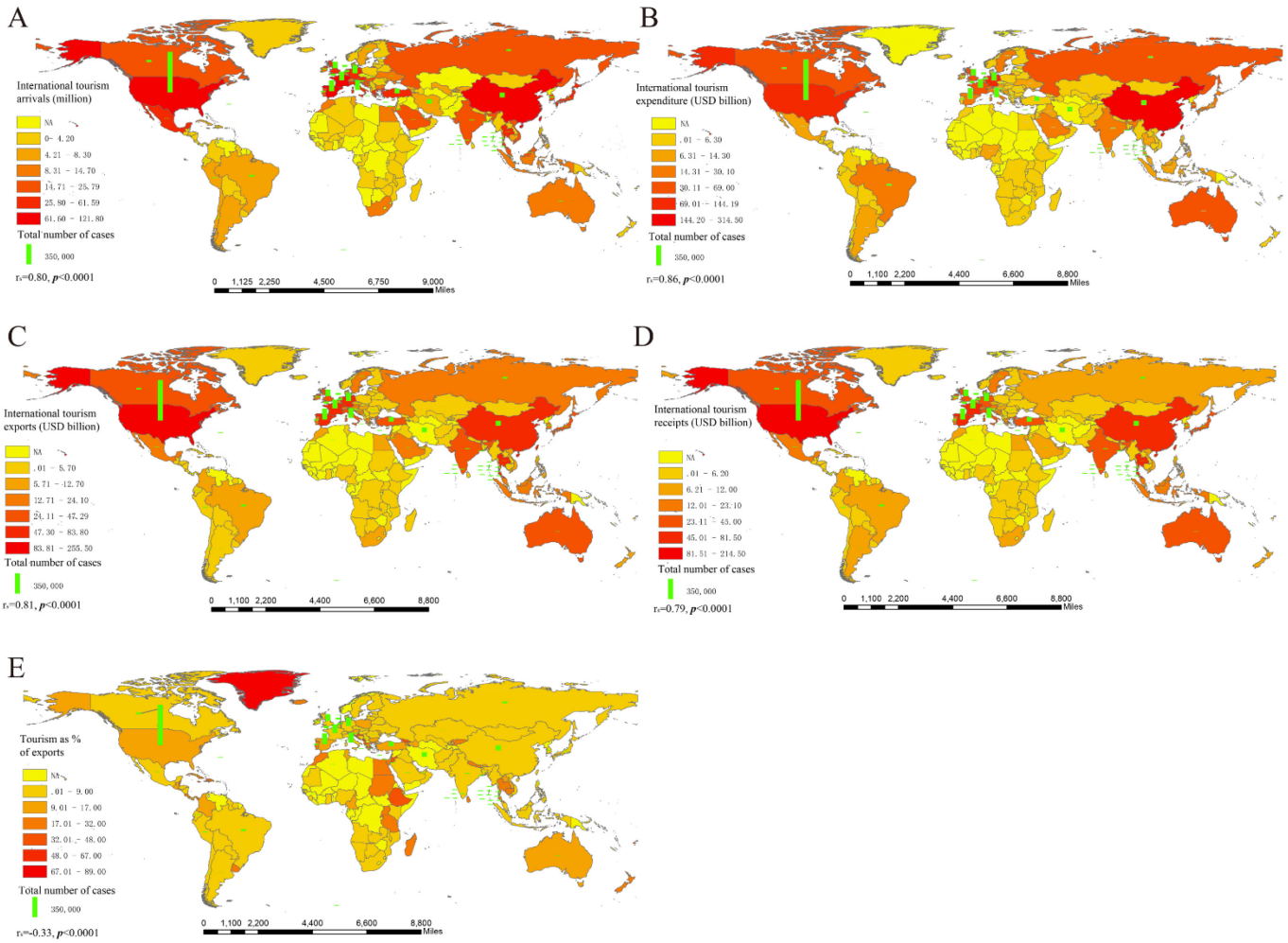
0.0001, respectively), ITEP (r_s = 0.85, p < 0.0001; r_s = 0.54, p = 0.001; r_s = 0.84, p < 0.0001, respectively), and TAOE (r_s = -0.50, p = 0.003; r_s = -0.344, p = 0.047; r_s = -0.497, p = 0.003, respectively). While the total number of cases and the daily growth of cases were negatively correlated with TAOE, with the correlation coefficients as -0.50 for both (p = 0.003 for both). Besides, the number of cases (per million persons) was only slightly correlated with ITEP (r_s = 0.44, p = 0.010), and no other significant associations were observed (p > 0.0125 for all). In the Middle East, only slight positive correlations were discovered between ITEP and the total number of cases (r_s = 0.66, p = 0.008), as well as the daily growth of cases (r_s = 0.65, p = 0.009).

Correlations between epidemic characteristics of COVID-19 and the tourism indicators in high and non-high-income countries/territories

In high-income countries/territories, we observed a robust positive correlation between the total number of cases, the daily growth of cases and ITED (r_s = 0.82, r_s = 0.80, respectively), ITR (r_s = 0.82, r_s = 0.79, respectively), ITA (r_s = 0.83, r_s = 0.81, respectively), ITEP (r_s = 0.85, r_s = 0.83, respectively) (p < 0.0001 for all). There were also lower correlations between the number of cases (per million persons) and ITED (r_s = 0.38, p = 0.006), ITR (r_s = 0.35, p=0.010), and ITEP (r_s = 0.38, p = 0.005). While no correlation was detected between average increase rate and all the tourism indicators (p > 0.0125 for all). In addition, there was no correlation between TAOE and and all the epidemic characteristics of COVID-19 (p > 0.0125 for all).

In places with non-high-income, several positive correlations were found between the total number of cases, the number of cases (per million persons), the daily growth of cases and ITED (r_s = 0.80, p < 0.0001; r_s = 0.31, p = 0.002; r_s = 0.76, p < 0.0001, respectively), ITR (r_s = 0.67, p < 0.0001; r_s = 0.34, p = 0.001; r_s = 0.64, p < 0.0001, respectively), ITA (r_s = 0.73, p < 0.0001; r_s = 0.29, p = 0.006; r_s = 0.69, p < 0.0001, respectively),

Figure 1. Total number of cases worldwide and the tourism indicators (the height of the straight bar in various countries/territories represents the total number of confirmed cases, the higher the bar, the higher the total confirmed cases).



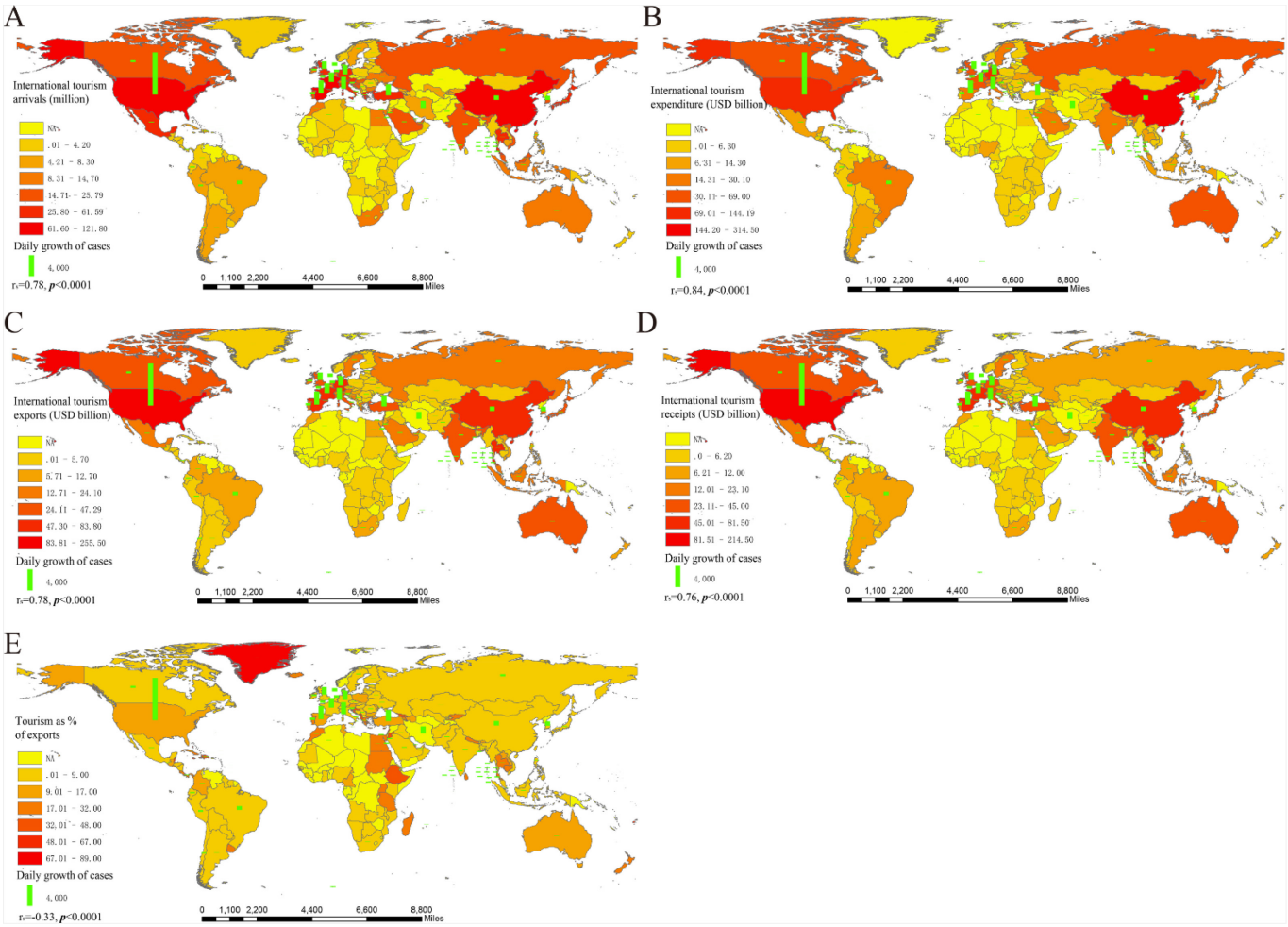
ITEP ($r_s = 0.69$, $p < 0.0001$; $r_s = 0.33$, $p = 0.001$; $r_s = 0.65$, $p < 0.0001$, respectively). However, no correlation exists among other variables ($p > 0.0125$) (Supplementary Table 2). In addition, the graph map of the total number of cases, the daily growth of cases, and the tourism indicators were shown in Figure 1 and Figure 2. Generally, we observed that countries/territories with relatively higher tourism indicators, including ITED, ITR, ITA, and ITEP, always had a more severe epidemic of COVID-19, which means more people were confirmed and the infections spread faster.

Discussion

In summary, places with higher tourism indicators (ITED, ITR, ITA and ITEP) are more prone to COVID-19, with more confirmed cases and faster transmission speed. Especially in high-income countries/territories (most of the countries/territories located in Europe and Americas). Positive correlations were discovered in various continents/regions between the epidemic characteristics of COVID-19 (total number of cases,number of cases (per million persons), daily growth of cases) and tourism indicators (ITED, ITR, ITA and ITEP). However, no correlation was detected for the number of cases (per million persons) and those tourism indicators in Africa and the Middle East.

It is well documented that infection transmission is highly associated with global trade and travel [17,1-3]. Besides, the yearly increasing numbers of tourism arrivals, higher shipping capacity levels, and a more considerable amount of air travel consumers resulted in the higher values of ITED, ITR, ITA, and ITEP [15,18,19]. In previous studies, researchers had reported a positive correlation between the number of international travelers and the incidence of imported diseases [20]. The remarkable infectivity of COVID-19 in the 21st century made it a great threat to mankind in

Figure 2. Daily growth of cases worldwide and the tourism indicators (the height of the straight bar in various countries/territories represents the number of the daily growth of cases, the higher the bar, the higher the daily growth of cases).



recent years. Till now, we still have not evidently recognized the way COVID-19 transmits. However, it has been shown that a man can easily be infected when exposed to an environment where an infected person coughs or sneezes [21]. Currently, travel business is developing with unprecedented speed, massive movement, and changes in environmental, technological, climatic, political, and social factors change converge to facilitate the emergence and further spread of COVID-19. As a result, places with higher tourism indicators, including ITED, ITR, and ITEP, presented a larger number of infected cases and a faster transmission speed.

Compared with countries/territories in Europe, Asia and Oceania, and the Americas, places in Africa and the Middle East did not present a significant correlation between the number of cases (per million persons) and ITED, ITR, ITA, ITEP. The reasons for such a phenomenon may be that the populations in some of these countries/territories are less than one million, such as Seychelles, Sao Tome Principe, Djibouti, etc. When calculating the number of cases (per million persons) in these places, the number of confirmed cases will be amplified, which might not reflect the real-time situation of COVID-19 epidemic. Also, the regional differences between the countries/territories with densely and non-densely population may also contribute to such results. Additionally, we noticed that TAOE was slightly negatively correlated to the number of cases and the daily growth of cases. For less developed countries/territories with relatively less developed economies, tourism always comprises an essential part of foreign exchange and exports [22]. However, there was evidence that tourists are more willing to visit places that are richer and more populated [23]. As a result, the mobility of humans and other factors that can contribute to the potential spread of infections in countries/territories with less developed economies was minor. As a result, fewer people were infected, and the transmission speed was low. As for the correlation for the average increase rate of cases and the tourism indicators, in the early period of the outbreak of COVID-19, the number of people infected by SARS-CoV-2 could increase several times compared with the previous day, while in the later stage, even the cases soaring, it is hardly double the number of cases in the previous day. Therefore, the average increase rate of cases was not correlated with the tourism indicators in most countries/territories.

As of early April 2020, the COVID-19 cases were mostly limited to regions and large urban centers, which have a more developed transportation system, dense population, and developed economy. Although our previous research indicated that people in countries with a developed economy, such as the United States, the United Kingdom, and Canada, had a relatively quicker response speed and had a longer duration of public attention toward COVID-19 due to their effective propaganda methods, the public awareness was not strong enough at the early stage of the outbreak of COVID-19 [8]. Therefore, countries with more developed tourism are required not only to increase investment to prevent and respond to new infectious epidemics but also to put efforts to strengthen public awareness of new infections. Meanwhile, although the epidemic of COVID-19 had a relatively lower impact in less developed countries/territories at the beginning of the outbreak, visits to this place continue to grow, primary prevention and more investment are also needed in less developed countries and territories against the outbreak of infectious diseases in the future [24]. Furthermore, due to the less developed healthcare system in less developed countries, the longer impact of COVID-19 is thus more severe, with more confirmed cases and deaths, the construction of basic health facilities and the help of the international community are needed to better respond to public emergencies. In addition, travelers themselves need to strengthen their awareness of self-protection. Aside from infectious diseases, it is reported that 30% of tourists had sought medical help for diarrhea, coldness, vomiting, and gastrointestinal illnesses [25]. Thus, more efforts are required to inform travelers about the risks of infectious diseases and other travel-related illnesses, strengthening their vigilance to take enough protective measures to stay away from infections and other diseases.

There are several potential limitations needed to be recognized. First, we only have access to the tourism data of 2018 from UNWTO, which would be a little different from that in 2019. Second, we did not obtain more detailed tourism information, and other characters of COVID-19 patients (gender, age, etc.) remain unclear. Thus, further analysis of tourism and the epidemic characteristics of COVID-19 infection is impossible. Besides, since the tourism industry was basically at a standstill after the outbreak of COVID-19, tourism is more likely to have contributed more to the spread of COVID-19 in the early stage. However, the lack of information after April 2020 is another limitation, further study should enlarge the information to 2020 and 2021, regarding the countries' measures regarding prevention of COVID-19 transmission.

Conclusions

In conclusion, there were strong correlations between tourism and the epidemic characteristics of COVID-19, particularly in developed countries/territories with high incomes. Clinical and health care providers in high-income countries/territories must realize the potential of global transmission of infectious diseases through travel and take effective preventive measures and strengthen public awareness to better respond to new infections. While more investment and international attention are needed to improve the construction of basic health facilities, strengthen the surveillance-warning system, build cost-effective models in places with less developed economy, so as to reduce the losses caused by the epidemic of infectious diseases.

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Authors' Contributions

FW conceived the study idea. DH collected the data. NM, XL, ZL, YT, FZ, and FW contributed to the analysis of the data. DH, NM, and XL wrote the initial draft with all authors providing critical feedback and edits to subsequent revisions. All authors approved the final draft of the manuscript. All authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. FW is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Annex – Supplementary items

Supplementary Table 1. Tourism indicators and epidemic characteristics of COVD-19 in 178 countries/territories.

Countries / Territories	ITED	ITR	ITA	ITEP	TAOE	Average increase rate	Daily growth of cases	Confirmed cases (per million)
Spain	26.8	81.5	82.8	81.5	16	0.21	2,511.03	4,081.70
Italy	30.1	49.3	61.6	51.8	8	0.23	2,239.38	2,851.95
Germany	95.6	43	38.9	60.3	3	0.19	1,745.63	1,687.64
France	47.9	65.5	89.4	73.3	8	0.16	1,775.32	2,284.68
United Kingdom	69.0	51.9	36.3	51.9	6	0.17	1,425.17	1,616.53
Belgium	18.5	8.9	9.1	10.4	2	0.20	495.03	3,118.14
Switzerland	17.5	17	11.7	20.3	5	0.33	520.71	3,128.73
Netherlands	21.2	18	18.8	25.2	3	0.30	612.30	1,786.77
Portugal	5.5	19.9	22.8	24.1	23	0.25	413.48	1,865.50
Austria	12	23.1	30.8	25.3	10	0.21	280.63	1,620.51
Russian Federation	34.3	11.5	24.6	18.7	4	0.15	415.66	219.33
Sweden	18.1	14.9	7.4	14.9	6	0.16	171.62	1,308.61
Ireland	7.4	6.2	10.9	14.7	4	0.27	291.23	2,831.11
Norway	17.3	5.8	5.7	7.1	4	0.27	136.00	1,279.60
Denmark	10.5	9.1	12.7	9.1	5	0.25	145.34	1,254.79
Czechia	6	7.5	-	8.2	4	0.20	139.28	611.54
Poland	9.7	14.0	19.6	15.8	5	0.29	190.41	221.39
Romania	4.3	2.8	2.8	3.3	3	0.22	158.16	419.33
Luxembourg	3.2	5	1	5.5	4	0.22	72.48	5,559.32
Serbia	1.4	1.3	1.7	1.7	7	0.30	135.45	651.23
Finland	6.1	3.7	3.2	5.7	5	0.13	44.15	629.70
Greece	2.6	17.3	30.1	20.1	24	0.21	43.59	213.37
Ukraine	7.9	1.4	14.2	2.3	4	0.25	103.58	106.60
Iceland	1.8	3.1	2.3	3.1	26	0.20	35.78	5,139.93
Croatia	1.7	11.8	16.6	12.1	35	0.18	34.87	441.87
Estonia	1.5	1.8	3.2	2.3	9	0.23	29.16	1,099.85
Moldova	0.4	0.4	0.2	0.5	12	0.25	56.58	561.23
Slovenia	1.6	3.2	4.4	3.4	6	0.21	30.28	627.25
Belarus	1.1	0.9	2.1	1.2	3	0.27	97.51	505.75
Hungary	2.6	6.9	17.2	6.9	4	0.18	40.02	182.50
Armenia	1.4	1.2	1.7	1.2	28	0.22	25.53	405.30
Lithuania	1.4	1.5	2.8	1.8	4	0.19	23.43	422.07
Bosnia and Herzegovina	0.3	1	1.1	1.1	12	0.17	28.19	370.03
Slovakia	2.6	3.2	-	3.3	3	0.22	24.95	192.14
North Macedonia	0.3	0.4	0.7	0.4	-	0.18	21.88	536.15
Bulgaria	1.9	4.5	9.3	5.1	12	0.18	21.05	121.75
Andorra	-	-	3	-	-	0.49	15.11	9,007.96
Latvia	0	1.1	1.9	1.1	5	0.18	14.80	361.57
Albania	1.7	2.2	5.3	2.3	36	0.22	13.77	187.30
Malta	0.5	1.9	2.6	1.9	10	0.14	10.22	955.75
San Marino	-	-	0.1	-	-	0.23	8.68	11,252.23
Montenegro	0.1	1.2	2.1	1.2	54	0.25	9.71	482.44
Monaco	-	-	0.3	-	-	0.14	1.94	2,395.27
Holy see	-	-		-	-	0.09	0.17	9,888.75
Liechtenstein	-	-	0.1	-	-	0.18	1.77	2,071.48
South Africa	3.4	8.9	10.5	9.8	9	0.24	64.70	46.92
Cameroon	0.7	0.6		0.6	10	0.21	23.69	37.52
Burkina Faso	-	-	0.1	-	-	0.25	14.63	26.65
Cote d'lvoire	-	-	2	-	-	0.28	18.57	26.08
Niger	-	-	0.2	-	-	0.31	22.36	25.90
Mauritius	0.6	1.9	1.4	2.2	39	0.23	10.70	254.76
Ghana	0.5	0.9	-	1	4	0.20	18.76	20.63
Nigeria	9.6	2	-	2	3	0.16	10.04	2.39
Senegal	-	-	-	-	-	0.17	7.41	20.43
Congo (Brazzaville)	-	-	0.2	-	-	0.27	4.30	25.91
Congo (Kinshasa)	0.1	0.1	-	0.1	0	0.21	7.73	3.20
Kenya	0.2	1.1	1.5	1.1	9	0.22	7.00	4.57

Guinea	0	0	-	0	0	0.23	13.60	36.32
Djibouti	0	0.1	-	0.1	9	0.32	24.37	740.89
Rwanda	0.3	0.4	-	0.5	24	0.24	4.18	11.04
Madagascar	0.2	0.7	0.3	0.9	21	0.20	4.07	4.23
Togo	-	-	0.6	-	-	0.25	1.95	10.03
Mali	-	-	0.2	-	-	0.25	7.35	8.44
Ethiopia	0.6	1	0.8	3.5	46	0.21	2.71	0.84
Uganda	0.2	1	1.9	1	21	0.38	2.04	1.22
Zambia	0.3	0.7	1.1	0.7	7	0.17	1.67	2.83
Gabon	-	-	-	-	-	0.19	3.15	48.52
Eritrea	-	-	-	-	-	0.21	1.26	9.87
Guinea-Bissau	0.1	0	-	0	5	0.22	1.78	21.85
Liberia	0	-	-	-	-	0.18	2.34	15.03
Benin	0.1	-	0.3	-	-	0.15	1.06	2.89
Tanzania	0.7	2.4	1.4	2.5	32	0.22	4.56	2.46
Angola	0.6	0.5	0.2	0.6	1	0.13	0.64	0.58
Equatorial Guinea	-	-	-	-	-	0.20	2.36	56.31
Mozambique	0.1	0.2	2.7	0.3	6	0.19	1.27	1.09
Namibia	0.1	0.4		0.5	8	0.07	0.41	6.30
Sudan	0	1	0.8	1	21	0.12	0.91	0.75
Somalia	-	-	-	-	-	0.20	3.59	7.30
Centr. African Rep.	-	-	-	-	-	0.13	0.33	2.48
Zimbabwe	-	-	2.6	-	-	0.16	0.82	1.61
Seychelles	0.1	0.6	0.4	0.6	39	0.06	0.26	111.86
Chad	-	-	-	-	-	0.16	0.90	1.64
Eswatini	0	0	0.8	0	1	0.14	0.44	13.79
Malawi	0.1	0	0.9	0	4	0.13	0.93	0.89
Cabo Verde	0.1	0.5	0.7	0.5	67	0.27	1.96	100.72
Sierra Leone	0.1	0	0.1	0	5	0.25	1.47	3.26
Mauritania	0	0	-	0	1	0.07	0.18	1.51
Botswana	0.3	0.6	-	0.6	8	0.12	0.67	6.38
Gambia	0	0.2	0.6	0.2	48	0.10	0.26	3.72
Sao Tome Principe	0	0.1	0	0.1	65	0.00	0.00	18.25
Burundi	0	0	-	0	1	0.07	0.18	0.42
China	305.1	117.7	110.7	124	1	0.09	854.28	57.87
Taiwan (China)	19.4	13.7	11.1	16.4	4	0.09	4.58	16.58
Korea (ROK)	35.1	18.6	15.3	23.1	3	0.20	854.68	207.43
India	21.3	28.6	17.4	29.1	5	0.17	183.99	10.40
Japan	20.2	42.1	31.2	45.3	5	0.10	105.22	77.38
Malaysia	12.2	19.6	25.8	21.8	8	0.10	63.23	162.24
Philippines	12.0	7.5	7.2	8.9	9	0.14	75.35	53.64
Pakistan	1.8	0.4	-	0.8	3	0.21	137.71	31.80
Indonesia	10.3	16.4	13.4	17.9	9	0.22	128.72	21.65
Thailand	12.4	63	38.2	68.1	20	0.09	28.40	38.68
Singapore	25.3	20.5	14.7	20.5	3	0.12	59.40	863.20
Kazakhstan	2.7	2.3	-	2.7	4	0.22	44.06	82.34
Uzbekistan	2.2	1.1	5.3	1.3	8	0.34	42.55	41.98
Azerbaijan	2.3	2.6	2.6	2.8	12	0.15	28.45	132.16
Afghanistan	0.2	0	-	0.1	3	0.18	17.08	23.27
Kyrgyzstan	0.3	0.4	6.9	0.5	19	0.23	16.20	74.95
Vietnam	5.7	10.1	15.5	10.1	4	0.07	3.13	2.75
Sri Lanka	1.7	4.4	2.3	5.6	28	0.09	3.00	11.39
Bangladesh	0.8	0.4	-	0.4	1	0.19	45.88	11.16
Georgia	0.5	3.2	4.8	3.5	45	0.16	7.24	92.75
Brunei	0.6	0.2	0.3	0.2	3	0.35	3.46	310.87
Cambodia	0.8	4.4	6.2	4.8	25	0.10	1.49	7.30
Burma	0.1	1.7	3.6	1.7	8	0.13	3.81	1.62
Maldives	0.4	3	1.5	3.1	84	0.05	0.60	51.80
Mongolia	0.9	0.4	0.5	0.5	6	0.16	0.79	9.46
Laos	0.9	0.7	3.8	0.8	12	0.11	0.71	2.61
Nepal	0.8	0.6	1.2	0.7	26	0.05	0.35	1.03
Bhutan	0.1	0.1	0.3	0.1	15	0.05	0.10	6.48
Timor-Leste	0.1	0.1	0.1	0.1	27	0.16	0.65	13.65

Australia	37	45	9.2	47.3	14	0.10	79.49	215.09
New Zealand	4.6	10.9	3.7	10.9	19	0.19	28.73	292.19
Fiji	0.1	1	0.9	1.4	52	0.12	0.55	18.96
Papua New Guinea	0	0	0.1	0	0	0.13	0.21	0.78
United States	144.2	214.5	79.7	255.5	10	0.20	8,042.59	2,113.90
Canada	34.4	26.4	21.1	26.4	5	0.15	400.00	869.08
Mexico	11.2	22.5	41.3	23.8	5	0.24	128.49	48.84
Panama	1.2	3.1	1.8	5.6	22	0.38	105.66	930.76
Dominican Rep.	0.5	7.6	6.6	7.6	37	0.23	87.77	380.35
Costa Rica	1	3.9	3	4	20	0.23	15.43	127.40
Cuba	-	2.9	4.7	3	22	0.18	25.56	81.49
Honduras	0.4	0.7	0.9	0.7	6	0.18	11.89	44.63
El Salvador	0.4	1	1.7	1.4	16	0.23	6.07	27.29
Guatemala	0.8	1.5	1.8	1.6	11	0.20	6.26	11.94
Barbados	-	1.1	0.7	1.1	64	0.16	2.35	260.99
Jamaica	0.3	3.1	2.5	3.1	54	0.20	3.84	48.29
Bahamas	0.4	3.4	1.6	3.4	86	0.17	1.66	137.32
Haiti	0.1	0.6	0.4	0.6	38	0.15	1.46	3.77
Antigua and Barbuda	0.1	0.9	0.3	1	83	0.14	0.63	234.87
Dominica	0	0.1	0.1	0.1	64	0.17	0.58	222.25
Saint Lucia	0.1	1	0.4	1	89	0.12	0.41	81.69
Grenada	0	0.5	0.2	0.5	84	0.26	0.50	124.42
St.Kitts and Nevis	0	0.4	0.1	0.4	56	0.14	0.52	263.20
St. Vincent and Gren	0	0.2	0.1	0.2	76	0.10	0.32	108.16
Belize	0	0.5	0.5	0.5	46	0.14	0.68	45.27
Nicaragua	0.2	0.5	1.3	0.5	9	0.10	0.28	1.36
Brazil	18.3	5.9	6.6	6.3	2	0.27	660.41	158.46
Chile	2.3	3	5.7	4	5	0.28	205.58	483.99
Ecuador	0.7	1.9	2.4	1.9	8	0.19	179.66	478.94
Peru	2.7	3.9	4.4	4.9	9	0.34	321.14	409.11
Colombia	4.8	5.6	3.9	6.6	13	0.26	81.86	67.59
Argentina	10.7	5.6	6.9	6	8	0.24	59.29	59.05
Uruguay	1.0	2.4	3.5	2.4	20	0.20	14.65	144.51
Bolivia	0.9	0.8	1.1	1	9	0.19	12.51	39.84
Venezuela	-	-	-	-	-	0.23	5.94	7.17
Paraguay	0.3	0.4	1.2	0.4	4	0.20	4.95	27.90
Trinidad and Tobago	0.1	0.4	0.4	0.5	5	0.21	3.29	81.46
Guyana	0.1	0	0.3	0	6	0.22	1.72	80.10
Suriname	0.1	0.1	-	0.1	3	0.12	0.26	17.05
Saudi Arabia	16.3	12	15.4	15.2	5	0.28	155.24	205.15
Iran	-	-	7.3	-	-	0.24	1,370.55	946.44
Iraq	7.9	2	-	2	2	0.20	27.94	36.85
Kuwait	14.3	0.5	-	0.9	1	0.30	31.26	388.24
Utd Arab Emirates	18	21.4	15.9	21.4	5	0.11	79.72	637.18
Oman	2.5	1.8	2.3	3	7	0.14	20.13	209.34
Qatar	9.3	5.6	1.8	15.2	15	0.37	97.13	1,618.50
Bahrain	2.7	3.7	4.4	3.8	13	0.51	32.81	1,022.58
Turkey	4.6	25.2	45.8	37.1	17	0.46	2,122.84	931.31
Israel	7.7	7.2	4.1	8.1	7	0.20	231.80	1,499.85
Syria	-	-	-	-	-	0.25	1.42	2.17
Lebanon	6.3	8.4	2	8.7	45	0.15	11.91	97.87
Jordan	1.4	5.2	4.2	6.2	41	0.26	9.02	39.89
Cyprus	1.6	3.5	3.9	3.5	21	0.19	19.18	621.19
Egypt	2.7	11.6	11.3	12.7	25	0.19	45.13	27.79
Libya	-	-	-	-	-	0.24	2.00	7.13
Tunisia	0.9	1.7	8.3	2.3	12	0.20	19.61	73.10
Algeria	-	-	2.7	-	-	0.19	46.48	55.14
Morocco	2	7.8	12.3	9.5	20	0.21	55.72	69.47

COVID-19: coronavirus diseases 2019 (COVID-19); ITED: International tourism expenditure (USD billion); ITR: International tourism receipts (USD billion); ITA: International tourist arrivals (million); ITEP: International tourism exports (USD billion); TAOE:Tourism as % of Exports.

Supplementary Table 2. Correlation between epidemic characteristics of COVID-19 and the tourism indicators in various continents/regions.

Continents/Regions	Epidemic characteristics of COVID-19		Tourism indicators				
			ITED	ITR	ITA	ITEP	TAOE
Europe	Total number of cases	r_s	0.88	0.77	0.75	0.82	-0.33
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.038
	Number of cases (per million persons)	r_s	0.46	0.48	0	0.49	-0.05
		p	0.003	0.002	0.994	0.001	0.766
	Average increase rate	r_s	-0.01	-0.08	0	-0.03	-0.12
		p	0.968	0.647	0.980	0.852	0.474
	Daily growth of cases	r_s	0.88	0.77	0.75	0.820	-0.34
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.034
Africa	Total number of cases	r_s	0.54	0.50	0.20	0.49	0
		p	0.001	0.005	0.321	0.006	0.994
	Number of cases (per million persons)	r_s	-0.01	0.02	-0.04	-0.07	0.29
		p	0.947	0.901	0.840	0.972	0.119
	Average increase rate	r_s	0.33	0.21	0.16	0.21	0.13
		p	0.062	0.256	0.435	0.271	0.496
	Daily growth of cases	r_s	0.52	0.46	0.27	0.45	0
		p	0.002	0.011	0.177	0.012	0.994
Asia and Oceania	Total number of cases	r_s	0.83	0.69	0.84	0.71	-0.42
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.014
	Number of cases (per million persons)	r_s	0.47	0.41	0.34	0.42	-0.07
		p	0.005	0.017	0.075	0.014	0.694
	Average increase rate	r_s	-0.09	-0.30	-0.11	-0.28	-0.31
		p	0.636	0.088	0.576	0.113	0.075
	Daily growth of cases	r_s	0.63	0.51	0.66	0.54	-0.46
		p	< 0.0001	0.002	< 0.0001	0.001	0.008
Americas	Total number of cases	r_s	0.91	0.82	0.89	0.85	-0.50
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.003
	Number of cases (per million persons)	r_s	0.32	0.42	0.28	0.44	0.15
		p	0.079	0.013	0.103	0.010	0.386
	Average increase rate	r_s	0.58	0.50	0.56	0.54	-0.34
		p	< 0.001	0.003	0.001	0.001	0.047
	Daily growth of cases	r_s	0.91	0.81	0.88	0.84	-0.50
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.003
Middle East	Total number of cases	r_s	0.58	0.61	0.48	0.66	-0.35
		p	0.024	0.015	0.069	0.008	0.195
	Number of cases (per million persons)	r_s	0.36	0.10	-0.13	0.27	-0.22
		p	0.191	0.713	0.639	0.334	0.442
	Average increase rate	r_s	0.07	-0.02	0.22	0.09	-0.07
		p	0.797	0.934	0.441	0.760	0.799
	Daily growth of cases	r_s	0.56	0.59	0.44	0.65	-0.34
		p	0.030	0.022	0.104	0.009	0.213
High-income countries / territories	Total number of cases	r_s	0.82	0.82	0.83	0.85	-0.30
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.029
	Number of cases (per million persons)	r_s	0.38	0.35	0.09	0.38	-0.08
		p	0.006	0.010	0.501	0.005	0.569
	Average increase rate	r_s	-0.03	-0.07	0.07	-0.01	-0.20
		p	0.857	0.596	0.635	0.948	0.163
	Daily growth of cases	r_s	0.80	0.79	0.81	0.83	-0.31
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.023
Non-high-income countries / territories	Total number of cases	r_s	0.80	0.67	0.73	0.69	-0.23
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.022
	Number of cases (per million persons)	r_s	0.31	0.34	0.29	0.33	0.21
		p	0.002	0.001	0.006	0.001	0.037
	Average increase rate	r_s	0.21	0.14	0.08	0.15	-0.02
		p	0.04	0.176	0.430	0.141	0.89
	Daily growth of cases	r_s	0.762	0.64	0.69	0.65	-0.24
		p	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.017

COVID-19: coronavirus diseases 2019 (COVID-19); ITED: International tourism expenditure (USD billion); ITR: International tourism receipts (USD billion); ITA: International tourist arrivals (million); ITEP: International tourism exports (USD billion); TAOE:Tourism as % of Exports.