

# The cruise industry and the COVID-19 outbreak

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## ABSTRACT

The movement of cruise ships has the potential to be a major trigger of coronavirus disease (COVID-19) outbreaks. In Australia, the cruise ship Ruby Princess became the largest COVID-19 epicenter. When the Ruby Princess arrived at the Port of Sydney in New South Wales on March 19, 2020, approximately 2700 passengers disembarked. By March 24, about 130 had tested positive for COVID-19, and by March 27, the number had increased to 162. The purpose of this study is to analyze the relationship between the cruise industry and the COVID-19 outbreak. We take two perspectives: the first analysis focuses on the relationship between the estimated number of cruise passengers landing and the number of COVID-19 cases. We tracked the movement of all ocean cruise ships around the world using automatic identification system data from January to March 2020. We found that countries with arrival and departure ports and with ports that continued to accept cruise ships until March have a higher COVID-19 infection rate than countries that did not. The second analysis focuses on the characteristics of cruise ships infected with COVID-19. For this purpose, we utilize the list named "Cruise ships affected by COVID-19" released by the Centers for Disease Control and Prevention. As a result, cruise ships infected with COVID-19 were large in size and operated regular cruises that sailed from the same port of arrival and departure to the same ports of call on a weekly basis.

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## 1. Introduction

Cruise ship movements can be a major trigger of coronavirus disease (COVID-19) outbreaks. In Australia, the cruise ship Ruby Princess became the largest COVID-19 epicenter. When the Ruby Princess arrived at the Port of Sydney on March 19, 2020, approximately 2700 passengers disembarked. On arrival, 130 passengers and crew members with flu-like symptoms were tested for the new virus. However, the officials of New South Wales allowed the other passengers to disembark before the test results were available. The next day, four people tested positive. Infection continued however, among the passengers who had disembarked, and the number rose to 162 by March 27 (Reuters, 2020).

Signs that cruise ships may become a source of infection had already appeared in early February. The largest cluster of COVID-19 cases outside mainland China occurred on board the Diamond Princess, which was quarantined in the port of Yokohama, Japan on February 3 (WHO, 2020). On March 6, cases of COVID-19 were identified on the Grand Princess off the coast of California; the ship was subsequently quarantined. By March

17, confirmed cases of COVID-19 had been associated with at least 25 additional cruise ships (CDC, 2020a).

The purpose of this study is to analyze the relationship between the cruise industry and the COVID-19 outbreak. We attempt the analysis from two perspectives. The first analysis focuses on the relationship between the estimated number of cruise passengers landing and the number of COVID-19 cases. The second analysis focuses on the characteristics of cruise ships infected with COVID-19. For the first analysis, we use automatic identification system (AIS) data to track the global movement of ocean cruise ships and estimate the number of cruise passengers landing in each country. In the second analysis, we compare ship sizes and itinerary characteristics from the CDC's list of cruise ships infected with COVID-19.

The remainder of this paper is structured as follows. Section 2 describes the analysis of cruise ship movement using AIS data. Section 3 shows the relationship between the estimated number of cruise passengers landing and COVID-19 outbreaks by country. In Section 4, we show the relationship between the on board characteristics of infected cruise ships and the COVID-19 outbreak and present a judgement for the moment, because the COVID-19 infection is continuously expanding. We conclude in Section 5.

## 2. Method description

In the first analysis in Section 3, we use AIS data to track the global movement of ocean cruise ships in service from January to March. We

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identify all ocean cruise ships registered as “Passenger/Cruise” on the ship registration database, [Maritime IHS \(2020\)](#). A total of 392 ocean cruise ships were in operation. The movement data are based on the date and time when the cruise ship enters the port. After obtaining movement data of the cruise ships at each port, we divide the data into ten cruise areas ([Appendix 1](#)). In the second analysis in [Section 4](#), we compare ship sizes and itinerary characteristics from the CDC's list of cruise ships infected with COVID-19 using ship data. With this, we analyze the characteristics of cruise ships infected with COVID-19.

### 3. Cruise passengers landing and the COVID-19 outbreak

#### 3.1. Tracking cruise ship movements from January to March

[Fig. 1](#) shows the total number of calls per week for each cruise area. The Caribbean has the largest number, followed by Oceania, South America, and North America. In terms of the number of port calls, the Caribbean is 400 to 450 times a week from January to February, 300 times in the second week of March, and approximately 50 times from the third week in March.

#### 3.2. Estimating cruise passengers landing by country

In order to observe the relationship between the number of cruise passengers landing and COVID-19 transmission, the former is calculated using Eq. (1).

$$L^i = \sum_{p \in P^i} \sum_{r \in R} x_{p,r} N_r C_r \quad (1)$$

$L^i$  represents the number of passengers landing in country  $i$ .  $P^i$  is a port in country  $i$ .  $R$  is all services for cruise products.  $N_r$  is the number of port calls for service  $r$ .  $C_r$  is the capacity of service  $r$ .  $x_{p,r}$  is 1 if service  $r$  calls at port  $p$ , and 0 otherwise. The number of cruise passengers landing by country from January to March and the number of COVID-19 cases by country until April 15 are calculated as shown in [Table 1](#). This study uses the capacity of cruise ships instead of actual passengers of cruise ships due to data unavailability. The US had the largest number of cruise passengers (4.71 million), followed by Mexico (2.06 million), Bahamas (1.90 million).

The US, which had a large number of cruise passengers landing, also had the largest number of COVID-19 cases at 609,516. However, Mexico

has the second largest number of cruise passengers with 5399 COVID-19 cases, while Bahamas, with the third largest, has only 49. In addition, Italy, which has a large number of COVID-19 cases, has the 10th largest number of cruise passengers, while Spain ranks 12th and the UK ranks 45th. In other words, countries with the highest number of cruise passengers did not necessarily have the highest number of COVID-19 cases.

#### 3.3. Analyzing the relationship between cruise passengers landing and the COVID-19 outbreak

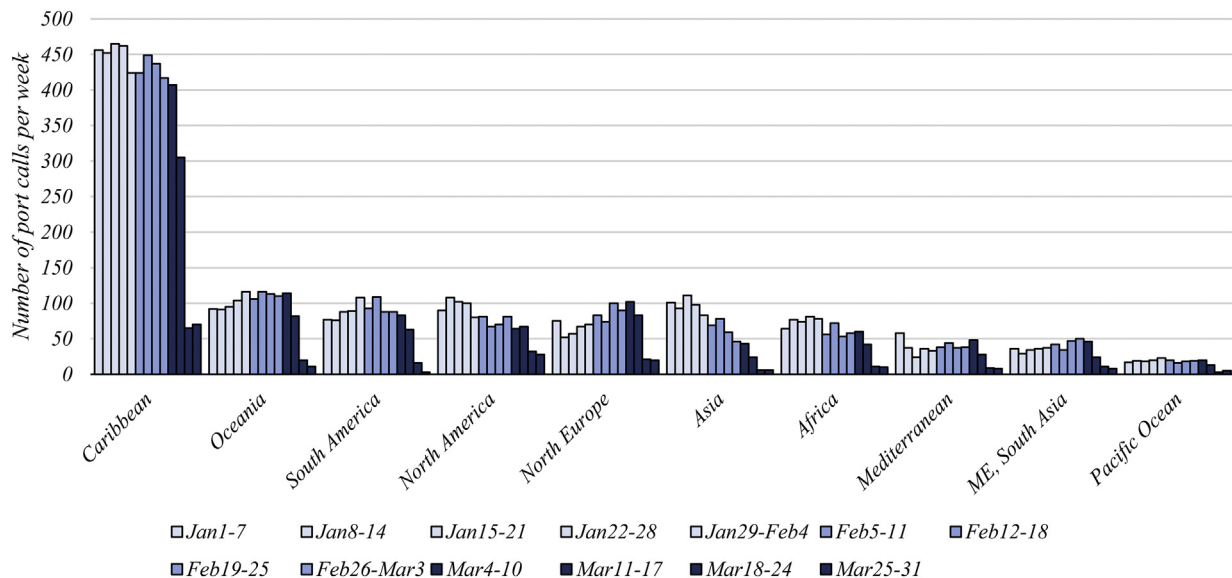
##### 3.3.1. COVID-19 infection rates between the port of arrival and departure and the port of call

In general, cruise passengers stay in the port city for a few days before embarking or after disembarking a ship. Conversely, the passengers spend only a few hours at the port of call. The time spent by cruise passengers at the arrival and departure ports tends to be longer than the time spent at the port of call. Therefore, we separately analyze the COVID-19 infection rate in countries with arrival and departure ports, and the COVID-19 infection rate in countries with only ports of call.

Unfortunately, AIS data can track ship movements, but not passenger movements. Therefore, we use [Expedia \(2020\)](#) cruise product search website. However, it should be noted that this website does not include cruise products directly sold by some cruise lines and travel agencies. Since our search was conducted in April, the results were different from the ports where ships actually arrived at and departed from January to March. In particular, more countries in the Northern Hemisphere, which have the best season for cruises from April, were included in the search results than countries in the Southern Hemisphere.

As of April 10, 18,501 items of ocean cruise products were sold. Using this site, all cruise products are sorted by port of arrival and departure and by country, as shown in [Appendix 2](#). The US accounted for 43%, followed by Italy, Spain, Canada, France, and Australia. In this analysis, we define these 30 countries as those with ports of arrival and departure.

The data in [Table 1](#) are divided into two groups: one for countries with arrival and departure ports and those without ports. Then, the following two indicators are used for comparison between the port of arrival and departure and the port of call. The first indicator is the number of COVID-19 cases relative to the number of cruise passengers landing. The results are shown in [Table 2](#). For the country of arrival and departure the figure was 12.85% and for country only at port of call it was 1.50%. It was found



**Fig. 1.** Number of port calls per week by cruise area.  
Source: Authors based on the AIS data.

**Table 1**

Estimated number of cruise passengers landing and COVID-19 Cases by country.

Source: Cruise passengers landing based on AIS data by authors, COVID-19 case data from [European Centre for Disease Prevention and Control, An agency of the European Union, 2020](#).

Countries and territories	Passengers landing <sup>a</sup>	COVID cases <sup>b</sup>	Countries and territories	Passengers landing <sup>a</sup>	COVID cases <sup>b</sup>	Countries and territories	Passengers landing <sup>a</sup>	COVID cases <sup>b</sup>	Countries and territories	Passengers landing <sup>a</sup>	COVID Cases <sup>b</sup>
1 United States of America	4,709,671	609,516	36 China	192,293	83,352	71 Mauritius	37,022	324	106 Senegal	2485	299
2 Mexico	2,066,815	5399	37 Madeira	181,981	N/A	72 Greece	36,794	2170	107 Ireland	2426	11,479
3 Bahamas	1,898,830	49	38 Colombia	181,875	2979	73 Cambodia	35,527	122	108 Ukraine	2310	3372
4 Australia	990,197	6416	39 Norway	181,156	6566	74 French Polynesia	34,680	55	109 Kenya	1844	216
5 Canary Islands	906,978	N/A	40 Guadeloupe	175,440	N/A	75 Seychelles	33,220	11	110 Monaco	1826	93
6 New Zealand	828,170	1078	41 South Africa	171,240	2415	76 Nicaragua	33,173	12	111 Faeroe Islands	1794	184
7 Brazil	800,283	25,262	42 Grenada	170,039	14	77 Namibia	31,449	16	112 Iceland	1794	1720
8 United Arab Emirates	738,397	4933	43 Costa Rica	147,621	618	78 Morocco	31,205	1888	113 Brunei Darussalam	1582	136
9 Puerto Rico	552,538	923	44 Sweden	135,060	11,445	79 Azores	29,081	N/A	114 Solomon Islands	1400	N/A
10 Italy	544,543	162,488	45 United Kingdom	134,451	93,873	80 Cape Verde Islands	27,096	11	115 St Helena Island	1200	N/A
11 Cayman Islands	542,079	54	46 Dominica	134,426	16	81 Turks & Caicos Islands	26,507	10	116 Gambia	1197	9
12 Spain	514,549	172,541	47 Finland	129,600	3161	82 Netherlands	25,053	27,419	117 Guam	1010	135
13 St Maarten	505,762	52	48 Vietnam	122,696	274	83 Indonesia	23,070	4839	118 Marshall Islands	1010	N/A
14 Virgin Islands (US)	496,695	N/A	49 Thailand	112,445	2643	84 Egypt	22,189	2350	119 Samoa	1000	N/A
15 Panama	471,607	3574	50 New Caledonia	112,187	18	85 Papua New Guinea	18,394	2	120 El Salvador	702	159
16 Barbados	439,705	73	51 Qatar	109,429	3428	86 Ecuador	17,714	7603	121 St-Martin	565	N/A
17 Argentina	357,881	2432	52 France	102,854	103,573	87 Cyprus	17,313	695	122 Isle of Man	530	242
18 St Lucia	334,828	15	53 Hong Kong	102,458	N/A	88 Israel	16,264	12,046	123 Angola	462	19
19 Malaysia	329,002	4987	54 St Vincent	99,916	12	89 Belgium	15,967	31,119	124 Cote d'Ivoire	462	626
20 Singapore	324,471	3252	55 India	92,717	11,438	90 Gibraltar	15,628	129	125 Ghana	462	636
21 Jamaica	316,344	105	56 Germany	83,264	127,584	91 Bermuda	14,848	57	126 Denmark	432	6511
22 Antigua	294,678	23	57 Philippines	76,473	5223	92 Cuba	13,314	766	127 Montserrat	286	11
23 Aruba	288,998	92	58 Vanuatu	72,502	N/A	93 Korea (South)	12,644	10,591	128 Palau	144	N/A
24 Curacao	287,688	14	59 Portugal	66,018	17,448	94 Russia	11,412	21,102	129 Timor-Leste	120	6
25 Dominican Republic	281,210	3286	60 Bahrain	59,661	1528	95 Jordan	5086	397	Total	26,471,816	1,757,368
26 St Kitts & Nevis	276,311	14	61 Taiwan	57,836	395	96 Falkland Islands	5060	11			
27 Honduras	270,339	419	62 Fiji	57,190	16	97 Croatia	5036	1704			
28 Uruguay	255,931	533	63 Guatemala	52,974	180	98 Mozambique	4615	28			
29 Japan	251,677	8100	64 Trinidad & Tobago	52,056	113	99 Tanzania	4025	N/A			
30 Martinique	250,879	N/A	65 Madagascar	50,682	108	100 Tonga	3716	N/A			
31 Virgin Islands (British)	248,096	N/A	66 Haiti	50,490	40	101 Cook Islands	3246	N/A			
32 Belize	246,921	18	67 Malta	46,237	393	102 Canada	3197	27,046			
33 Chile	212,779	7917	68 Peru	42,583	10,303	103 American Samoa	3000	N/A			
34 Bonaire	207,577	4	69 Reunion	42,328	N/A	104 Turkey	2995	65,111			
35 Oman	199,333	910	70 Sri Lanka	37,861	233	105 Northern Mariana Islands	2680	13			

<sup>a</sup> The number of cruise passengers landing is from January 1, 2020 to March 31, 2020.<sup>b</sup> The number of COVID-19 cases is from December 2019 to April 15, 2020.

that the number of COVID-19 cases against the number of cruise passengers landing at the country of arrival and departure was 11.35% points higher. The second indicator is the COVID-19 infection rate to express the number of COVID-19 cases per population. The COVID-19 infection rate in the country of arrival and departure was 0.057%, while that in the country of port of call was 0.006%. It was found that the COVID-19 infection rate in the country of arrival and departure tended to be 0.051% points higher.

Lekakou et al. (2009) proposed that the convenience of an international airport is a necessary condition for cities with arrival and departure ports. Based on an analysis of cruise home ports, Castillo-Manzano et al. (2014) suggested that the likelihood of having cruise traffic was linked to the ports location in populous areas and being close to large airports. In other words, cities with ports of arrival and departure are characterized by proximity to an international airport. Therefore, it should be noted that there are many tourists who are not cruise passengers because of the international airport nearby.

### 3.3.2. Comparison of port call and COVID-19 infection

There may also be some relationship between the timing of port call and the timing of the COVID-19 outbreak expansion. Fig. 2 shows the number of port calls by day for the top 30 ports from January to March. A dark color filled box indicates a day with many port calls, while white means no port calls in a day. Most of the top 30 ports accepted cruise ships until mid-March when CLIA announced that the cruise ships had stopped operating (CLIA, 2020). In particular, Caribbean ports such as Cozumel (Mexico), Miami (US) and Nassau (Bahamas) continued to accept cruise ships.

Considering the 14-day incubation period, the number of people infected with COVID-19 in mid-April may be related to the acceptance of cruise ships in March. Therefore, we compare COVID-19 infection rates among countries that had reduced the acceptance of cruise ships in March and those that did not. The 129 countries in Table 1 where cruise ships called from January to March, the number of cruise passengers landing in March was arranged in descending order. These countries are then divided

**Table 2**

COVID-19 infection rates between countries with arrival and departure ports and countries with only ports of call.

Source: Authors.

	Cruise passengers landing <sup>a</sup>	Population	COVID-19 cases <sup>b</sup>	COVID-19 cases/passengers landing	COVID-19 infection rate
	a	b	c	d = c/a	e = c/b
(A) Country of arrival and departure	12,314,032	2,788,910,590	1582,558	12.85%	0.057%
(B) Country only at port of call	11,689,288	3,023,378,663	174,810	1.50%	0.006%
(A) - (B)	624,744	−234,468,073	1,407,748	11.35%pt	0.051%pt

<sup>a</sup> The number of cruise passengers landing is from January 1, 2020 to March 31, 2020.<sup>b</sup> The number of COVID-19 cases is from December 2019 to April 15, 2020.

into two groups for analysis. The top half countries are defined as the group that continued to accept cruise ships in March. On the other hand, the lower half countries are defined as the group that had reduced the acceptance of cruise ships in March.

As a result, Fig. 3 shows the COVID-19 infection rate of the former group was 0% in January–February, but increased to 0.016% in March. By the mid-April, it has increased to 0.028%. Conversely, COVID-19 infection rate of the latter group was flat at 0.003% in February, 0.002% in March, and 0.006% in mid-April. The results show that the COVID-19 infection rate in countries that had reduced the acceptance of cruise ships in March was lower than that of the countries that continued to accept cruise ships in March.

As shown in Fig. 2, major cruise ports continued to accept cruise ships even until mid-March. This indicates that the decision of stopping a cruise operation cannot be made by each cruise line alone. Similarly, the

suspension of port operations also cannot be decided by each port individually. The following viewpoints can offer some reasons.

According to Bagis and Dooms (2014), the purpose of the cruise business is to maximize profits by using ships with huge investments. Suspension of cruise ships will lead to reduced profits and, in the worst case, bankruptcy. According to Henry (2012), general itinerary planning by a cruise line takes place some 2–3 years prior to an actual voyage. If one port is closed, a cruise line cannot immediately call at another port. Due to these circumstances, even if the risk of infection from a cruise ship is increasing, it is not easy for a cruise line to take a management decision to suspend cruise operations.

Even for the port, closing the port is also a difficult decision. One of the reasons for this is the fierce competition between neighboring ports. Recently, the bargaining power on the port side becomes weaker than that of the cruise line. Port closures may lead to the elimination of future port

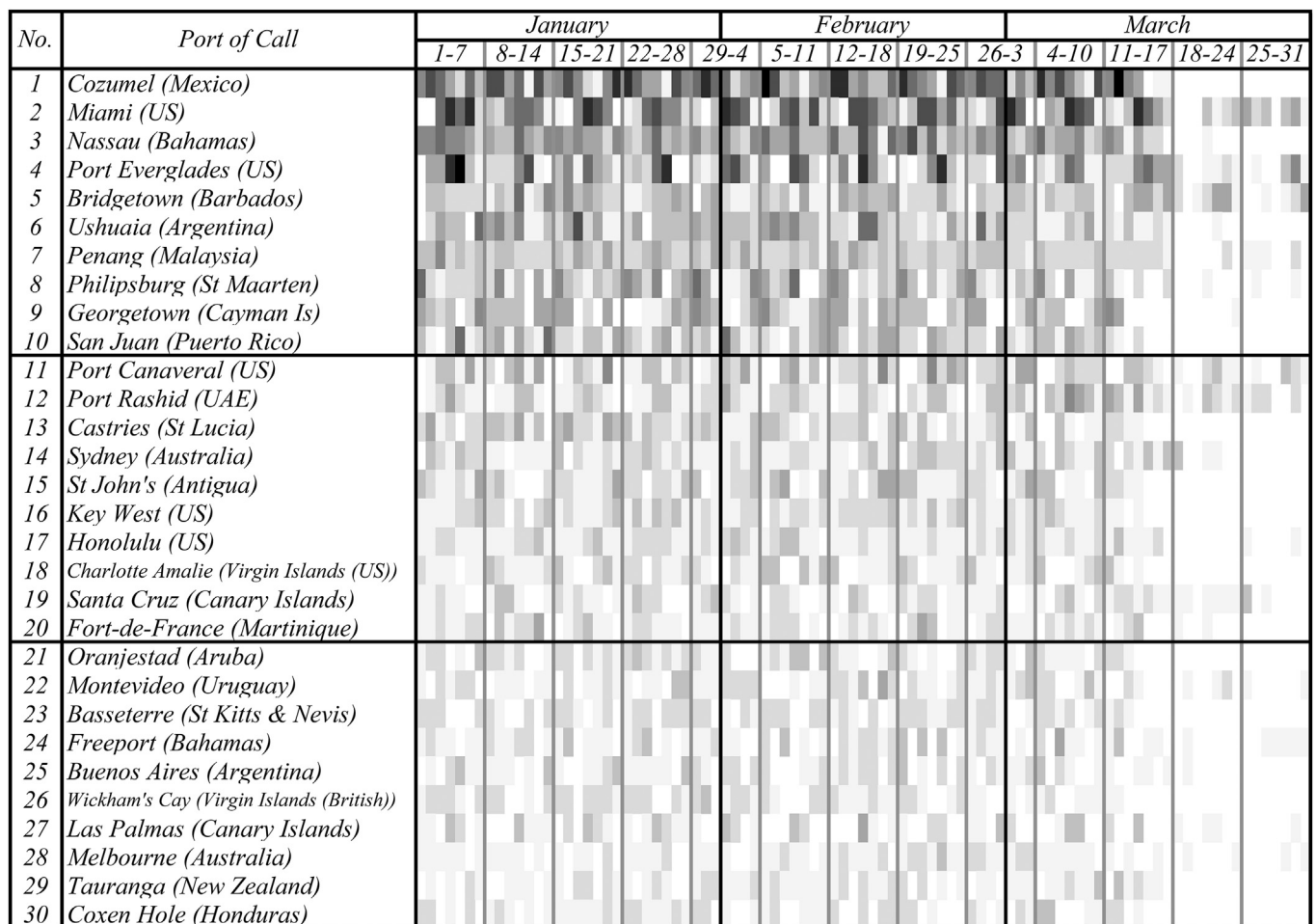


Fig. 2. Number of port calls for each port from January to March. Note: A dark color filled box indicates a day with many port calls, while white means no port calls in a day. Source: Authors based on the AIS data.



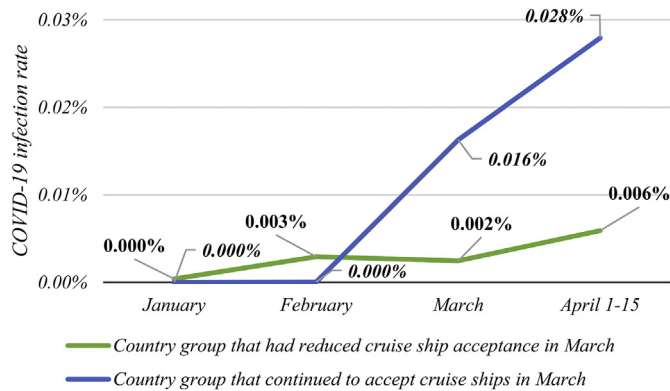


Fig. 3. COVID-19 infection rate for groups accepting cruise ships and reducing cruise ships in March.

Source: Authors.

calls. According to Pallis et al. (2018), investment in ports by cruise lines is accelerating. In recent years, cruise lines have invested in ports and have exclusive cruise terminals for their ships. The trend of privatization leads to a decrease in interest in cruises on the port side. Poor interest in the cruise business on the port side may have led to a delay in the decision to close ports.

#### 4. Characteristics of cruise ships with infection on board and the COVID-19 outbreak

According to the “Cruise ships affected in US by COVID-19” (CDC, 2020b), the cruise ships listed in Appendix 3 made voyages discovered to be infected with COVID-19. We analyze the characteristics of these cruise ships infected with COVID-19 from two perspectives: the ship size and ship operation schedule.

Fig. 4 shows the passenger capacities of cruise ships that were in operation between January and March, which are arranged in order of size of ship. A total of 594 vessels were analyzed, including river cruises. The median and average for all cruise ships are 312 and 1238 passengers, respectively. The passenger capacity of all infected cruise ships was above the

median and average. It is clear that cruise ships infected with COVID-19 are large ships.

The second indicator is a ship operation schedule (itinerary). Table 3 shows the itinerary of eight large cruise ships before the COVID-19 infection was confirmed. These itineraries had several characteristics. The first is an itinerary that repeats one week for seven nights and eight days. Second is the itinerary, where the arrival and departure port (home port) is fixed. Third, the port of call as a destination is also fixed. These itineraries include private islands owned by each cruise line as ports of call.

The risk of infection on board a ship increases proportionately as the number of passengers increases. Cruise ships with an unspecified number of cruise passengers replacing in a week may have a higher infection rate than ships that do not have passengers replacing for several weeks. In the case of a large cruise ship with many passengers aboard, due to the limited number of persons in charge of inspection, there is a possibility that health inspection may not be strict.

#### 5. Conclusions

The purpose of this study is to analyze the relationship between the cruise industry and the COVID-19 outbreak. We analyzed this from two perspectives.

The first analysis focused on the relationship between the cruise ship movement and the COVID-19 outbreak. Consequently, it was found that COVID-19 infection rates in countries that have ports of arrival and departure are higher than in countries with only ports of call. In addition, COVID-19 infection rates in countries that continued to accept cruise ships until March were higher than those in countries that did not. However, we used the estimated number of cruise passengers landing in each country by AIS data to track cruise ships. The estimated figures differ from the actual ones; thus, it is necessary to get the actual data from the cruise lines. The second analysis focused on the characteristics of cruise ships infected with COVID-19. We compared ship sizes and itinerary characteristics from the CDC's list of cruise ships infected with COVID-19. We found that the cruise ships infected with COVID-19 were large. In addition, most cruise ships were sailing from the same home port to the same port of call in a week's time.

The emergence of the modern cruise industry began in the late 1960s and early 1970s (Garin, 2005). The cruise industry has shown remarkable resilience in the face of economic, social political, and other crises. The

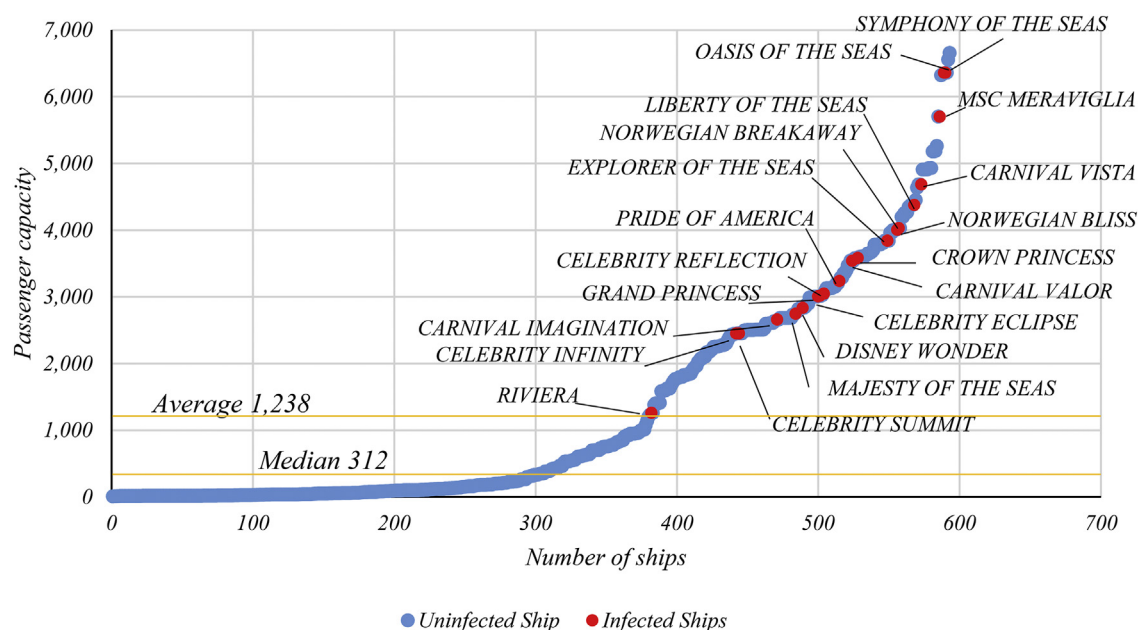


Fig. 4. Passenger capacity of cruise ships infected with COVID-19.

Source: Authors.

**Table 3**

Itinerary of cruise ships infected with COVID-19 (top 8 large ships).

Source: Authors based on AIS data.

SYMPHONY OF THE SEAS				OASIS OF THE SEAS				MSC MERAVIGLIA				CARNIVAL VISTA			
Day1	2020/2/15	Miami	US	Day1	2020/2/9	Miami	US	Day1	2020/2/9	Miami	US	Day1	2020/2/1	Galveston	US
Day3	2020/2/17	Coxen Hole	Honduras	Day4	2020/2/12	Falmouth Port	Jamaica	Day3	2020/2/11	Ocho Rios	Jamaica	Day3	2020/2/3	Cozumel	Mexico
Day4	2020/2/18	Puerto Coasta Maya	Mexico	Day6	2020/2/14	Cozumel	Mexico	Day4	2020/2/12	Georgetown	Cayman Islands	Day4	2020/2/4	Belize City	Belize
Day5	2020/2/19	Cozumel	Mexico	Day8	2020/2/16	Miami	US	Day5	2020/2/13	Cozumel	Mexico	Day8	2020/2/8	Galveston	US
Day7	2020/2/21	Slaughter Harbour	Bahamas	Day1	2020/2/16	Miami	US	Day7	2020/2/15	Ocean Cay	Bahamas	Day1	2020/2/8	Galveston	US
Day8	2020/2/22	Miami	US	Day3	2020/2/18	Labadee	Haiti	Day8	2020/2/16	Miami	US	Day3	2020/2/10	Cozumel	Mexico
Day1	2020/2/22	Miami	US	Day4	2020/2/19	San Juan	Puerto Rico	Day1	2020/2/16	Miami	US	Day4	2020/2/11	Georgetown	Cayman Islands
Day4	2020/2/25	Philipsburg	St Maarten	Day5	2020/2/20	St Thomas	Virgin Islands (US)	Day3	2020/2/18	Coxen Hole	Honduras	Day5	2020/2/12	Ocho Rios	Jamaica
Day5	2020/2/26	San Juan	Puerto Rico	Day8	2020/2/23	Miami	US	Day4	2020/2/19	Belize City	Belize	Day8	2020/2/15	Galveston	US
Day7	2020/2/28	Slaughter Harbour	Bahamas	Day1	2020/2/23	Miami	US	Day5	2020/2/20	Puerto Coasta Maya	Mexico	Day1	2020/2/15	Galveston	US
Day8	2020/2/29	Miami	US	Day6	2020/2/28	Cozumel	Mexico	Day8	2020/2/23	Miami	US	Day3	2020/2/17	Cozumel	Mexico
Day1	2020/2/29	Miami	US	Day8	2020/3/1	Miami	US	Day1	2020/2/23	Miami	US	Day4	2020/2/18	Belize City	Belize
Day3	2020/3/2	Coxen Hole	Honduras	Day1	2020/3/2	Miami	US	Day3	2020/2/25	Ocho Rios	Jamaica	Day8	2020/2/22	Galveston	US
Day4	2020/3/3	Puerto Coasta Maya	Mexico	Day3	2020/3/4	Philipsburg	St Maarten	Day5	2020/2/27	Cozumel	Mexico	Day1	2020/2/22	Galveston	US
Day5	2020/3/4	Cozumel	Mexico	Day4	2020/3/5	San Juan	Puerto Rico	Day8	2020/3/1	Miami	US	Day3	2020/2/24	Cozumel	Mexico
Day7	2020/3/6	Coco Cay	Bahamas	Day7	2020/3/8	Miami	US	Day1	2020/3/1	Miami	US	Day4	2020/2/25	Georgetown	Cayman Islands
Day8	2020/3/7	Miami	US	Day1	2020/3/8	Miami	US	Day5	2020/3/4	Belize City	Belize	Day5	2020/2/26	Ocho Rios	Jamaica
Day1	2020/3/7	Miami	US	Day6	2020/3/13	Cozumel	Mexico	Day5	2020/3/5	Coxen Hole	Honduras	Day8	2020/2/29	Galveston	US
Day4	2020/3/10	Basseterre	St Kitts & Nevis	Day6	2020/3/15	Miami	US	Day8	2020/3/8	Miami	US	Day1	2020/2/29	Galveston	US
Day5	2020/3/11	St Thomas	Virgin Islands (US)									Day5	2020/3/4	Belize City	Belize
Day7	2020/3/13	Coco Cay	Bahamas									Day6	2020/3/5	Cozumel	Mexico
Day8	2020/3/14	Miami	US									Day8	2020/3/7	Galveston	US
LIBERTY OF THE SEAS				NORWEGIAN BREAKAWAY				NORWEGIAN BLISS				EXPLORER OF THE SEAS			
Day1	2020/2/23	Galveston	US	Day1	2020/2/8	Port Canaveral	US	Day1	2020/2/18	Port Canaveral	US	Day1	2020/2/16	Miami	US
Day3	2020/2/25	Cozumel	Mexico	Day4	2020/2/11	Wickham's Cay	Virgin Islands (British)	Day3	2020/2/20	Nassau	Bahamas	Day3	2020/2/18	Nassau	Bahamas
Day4	2020/2/26	Georgetown	Cayman Islands	Day5	2020/2/12	San Juan	Puerto Rico	Day6	2020/2/23	New York & New Jersey	US	Day5	2020/2/20	Nassau	Bahamas
Day8	2020/3/1	Galveston	US	Day7	2020/2/14	Slaughter Harbour	Bahamas	Day8	2020/2/25	Port Canaveral	US	Day6	2020/2/21	Miami	US
Day1	2020/3/1	Galveston	US	Day8	2020/2/15	Port Canaveral	US	Day1	2020/2/25	Port Canaveral	US	Day1	2020/2/21	Miami	US
Day4	2020/3/4	Coxen Hole	Honduras	Day1	2020/2/15	Port Canaveral	US	Day2	2020/2/26	Slaughter Harbour	Bahamas	Day5	2020/2/25	Oranjestad (Aruba)	Aruba
Day6	2020/3/6	Cozumel	Mexico	Day5	2020/2/19	Georgetown	Cayman Islands	Day3	2020/2/27	Nassau	Bahamas	Day6	2020/2/26	Kralendijk	Bonaire
Day8	2020/3/8	Galveston	US	Day6	2020/2/20	Cozumel	Mexico	Day6	2020/3/1	New York & New Jersey	US	Day7	2020/2/27	Willemstad West Bank	Curacao
Day1	2020/3/8	Galveston	US	Day8	2020/2/22	Port Canaveral	US	Day8	2020/3/3	Port Canaveral	US	Day10	2020/3/1	Miami	US
Day3	2020/3/10	Cozumel	Mexico	Day1	2020/2/22	Port Canaveral	US	Day1	2020/3/3	Port Canaveral	US	Day1	2020/3/1	Miami	US
Day4	2020/3/11	Georgetown	Cayman Islands	Day4	2020/2/25	Wickham's Cay	Virgin Islands (British)	Day2	2020/3/4	Great Stirrup Cay	Bahamas	Day4	2020/3/4	San Juan	Puerto Rico
Day5	2020/3/12	Falmouth Port	Jamaica	Day5	2020/2/26	Charlotte Amalie	Virgin Islands (US)	Day3	2020/3/5	Nassau	Bahamas	Day5	2020/3/5	St Thomas	Virgin Islands (US)
Day8	2020/3/15	Galveston	US	Day8	2020/2/29	Port Canaveral	US	Day6	2020/3/8	New York & New Jersey	US	Day7	2020/3/7	Freeport (Bahamas)	Bahamas
Day1	2020/3/15	Galveston	US	Day1	2020/2/29	Port Canaveral	US	Day8	2020/3/10	Port Canaveral	US	Day8	2020/3/8	Miami	US
Day7	2020/3/21	South Sabine Point STS	US	Day4	2020/3/3	Falmouth Port	Jamaica	Day1	2020/3/10	Port Canaveral	US	Day1	2020/3/8	Miami	US
Day8	2020/3/22	Galveston	US	Day5	2020/3/4	Georgetown	Cayman Islands	Day2	2020/3/11	Great Stirrup Cay	Bahamas	Day3	2020/3/10	San Juan	Puerto Rico
Day1	2020/3/22	Galveston	US	Day6	2020/3/5	Cozumel	Mexico	Day3	2020/3/12	Nassau	Bahamas	Day4	2020/3/11	Charlotte Amalie	Virgin Islands (US)
Day6	2020/3/27	South Sabine Point STS	US	Day8	2020/3/7	Port Canaveral	US	Day6	2020/3/15	New York & New Jersey	US	Day8	2020/3/15	Miami	US
Day8	2020/3/29	Galveston	US	Day1	2020/3/7	Port Canaveral	US	Day11	2020/3/20	Miami	US				
				Day6	2020/3/12	Cozumel	Mexico								
				Day8	2020/3/14	Port Canaveral	US								

Darker color indicates an itinerary infected with COVID-19.

global financial crisis of 2008–2009 had a serious impact on the maritime cargo shipping industry. However, the cruise industry has continued to grow steadily. When the Costa Concordia loss (2012) created a period of negative publicity for the cruise industry, the industry cruised “through the perfect storm” (Peisley, 2012) and continued to generate more demand in large part due to the successful marketing strategies developed by the cruise lines (Pallis et al., 2018). Vogel and Oschmann (2012) explained that cruise demand has always been “supply-led” starting with the invention of leisure cruising by passenger shipping lines whose scheduled transatlantic services were losing passengers to the airlines. Similarly, Rodrigue and Notteboom (2013) analyzed that the cruise industry works in a “supply push mechanism” as cruise lines aim to generate demand for cruises by providing new products with a larger and more diversified range of ships. The impact of COVID-19 on the cruise industry will be much stronger than any of the past difficulties. However, the cruise industry will grow again with a new supply-driven strategy as overcoming difficulties in the past. We hope that the results of this study will be useful not only for academic researchers, but also for executives of the cruise industry and port officials.

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### CRedit authorship contribution statement

**Hirohito Ito:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft. **Shinya Hanaoka:** Supervision, Resources, Writing - review & editing, Validation. **Tomoya Kawasaki:** Writing - review & editing, Validation.

### Appendix 1. List of cruise areas and countries

Cruise area	Country
North America	Canada, Costa Rica (West coast), El Salvador, Guatemala (West coast), Mexico (West coast), Nicaragua, Panama (West coast), St Pierre and Miquelon, US (North east coast, West coast)
Caribbean Sea	Antigua, Aruba, Bahamas, Barbados, Belize, Cayman Islands, Colombia, Costa Rica (East coast), Cuba, Dominica, Dominican Republic, French Guiana, Grenada, Guadeloupe, Guatemala (East coast), Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico (East coast), Montserrat, Netherlands Antilles, Panama (East coast), Puerto Rico, St Kitts & Nevis, St Lucia, St Vincent, Suriname, Trinidad & Tobago, Turks & Caicos Islands, US (South east coast), Venezuela, Virgin Islands
South America	Argentina, Brazil, Chile (West coast), Ecuador, Falkland Islands, Peru, South Georgia, Uruguay
Pacific Ocean	Chile (Around Easter island), US (Around Hawaii islands)
Oceania	American Samoa, Australia, Christmas Island, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, New Caledonia, New Zealand, Norfolk Island, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu
Asia	Brunei, Cambodia, China, Indonesia, Japan, Myanmar, Philippines, Russia, Singapore, South Korea, Taiwan, Thailand, Timor, Vietnam
Middle East, South Asia	Bahrain, Egypt, India, Iran, Israel, Jordan, Kuwait, Maldives, Oman, Pakistan, Qatar, Saudi Arabia, Sri Lanka, United Arab Emirates, Yemen
Mediterranean Sea	Albania, Algeria, Bulgaria, Croatia, Cyprus, Egypt, France (South coast), Gibraltar, Greece, Israel, Italy (South coast), Lebanon, Libya, Malta, Monaco, Montenegro, Romania, Russia (West coast), Slovenia, Spain (South coast), Syria, Tunisia, Turkey, Ukraine
Northern Europe	Belgium, Channel Islands, Denmark, Estonia, Faroe Islands, Finland, France (North coast), Germany, Greenland, Guernsey, Iceland, Ireland, Isle of Man, Jersey, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Russia (North coast, East coast), Spain, Sweden, UK
Africa	Angola, Benin, Cameroon, Canary Islands, Cape Verde Islands, Comoros, Congo (Republic), Cote d'Ivoire, Djibouti, Eritrea, Gabon, Gambia, Ghana, Guinea, Kenya, Liberia, Madagascar, Madeira, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Reunion, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Western Sahara

Source: Authors.

### Appendix 2. Top 30 countries with ports of arrival and departure among cruise products sold in early April

Rank	Countries with arrival and departure ports	Number of products	Cumulative Percentage
1	United States	7930	42.9%
2	Italy	2834	58.2%
3	Spain	1054	63.9%
4	Canada	715	67.7%
5	France	693	71.5%
6	Australia	467	74.0%
7	Greece	392	76.1%
8	United Kingdom	386	78.2%
9	Ecuador	369	80.2%
10	Denmark	283	81.7%
11	Germany	280	83.3%
12	Japan	272	84.7%
13	Puerto Rico	266	86.2%
14	Netherlands	253	87.5%
15	United Arab Emirates	247	88.9%
16	Singapore	171	89.8%
17	Brazil	167	90.7%
18	Argentina	140	91.4%
19	Barbados	120	92.1%
20	China	120	92.7%
21	Turkey	109	93.3%
22	Sweden	104	93.9%
23	South Africa	100	94.4%
24	Hong Kong	93	94.9%
25	Martinique	89	95.4%
26	New Zealand	78	95.8%
27	Portugal	63	96.2%
28	Norway	54	96.5%
29	Qatar	44	96.7%
30	Monaco	41	96.9%
Others		567	100.0%
Total		18,501	–

Source: Authors based on the Expedia, 2020 cruise product search site.

### Appendix 3. Cruise ships affected in US by COVID-19

Ship name	Voyage start date	Voyage end date
Carnival Imagination	5-Mar	8-Mar
Carnival Valor	29-Feb	5-Mar
Carnival Valor	5-Mar	9-Mar
Carnival Valor	9-Mar	14-Mar
Carnival Vista	15-Feb	22-Feb
Carnival Vista	29-Feb	7-Mar
Celebrity Infinity	5-Mar	9-Mar
Celebrity Eclipse <sup>a</sup>	2-Mar	30-Mar
Celebrity Reflection	13-Mar	17-Mar
Celebrity Summit	29-Feb	7-Mar
Crown Princess	6-Mar	16-Mar
Disney Wonder	28-Feb	2-Mar
Disney Wonder <sup>a</sup>	6-Mar	20-Mar
Grand Princess	11-Feb	21-Feb
Grand Princess <sup>a</sup>	21-Feb	7-Mar
MSC Meraviglia	1-Mar	8-Mar
Norwegian Bliss <sup>a</sup>	1-Mar	8-Mar
Norwegian Bliss	8-Mar	15-Mar
Norwegian Breakaway	29-Feb	7-Mar
Norwegian Breakaway <sup>a</sup>	7-Mar	14-Mar
Norwegian Pride of America <sup>a</sup>	29-Feb	7-Mar
Oceania Riviera <sup>a</sup>	26-Feb	11-Mar
RCCL Explorer of the Seas	8-Mar	15-Mar
RCCL Liberty of the Seas <sup>a</sup>	15-Mar	29-Mar
RCCL Majesty of the Seas <sup>a</sup>	29-Feb	7-Mar
RCCL Oasis of the Seas <sup>a</sup>	8-Mar	15-Mar
RCCL Symphony of the Seas <sup>a</sup>	7-Mar	14-Mar

Source: Centers for Disease Control and Prevention.

<sup>a</sup> CDC was notified of COVID-19-positive travelers who had symptoms while on board these ships.

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