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# Commercial airline protocol during COVID-19 pandemic: An experience of Thai Airways International --Manuscript Draft--

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Full Title:	Commercial airline protocol during COVID-19 pandemic: An experience of Thai Airways International			
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Keywords:	COVID-19; aviation; Thailand; SARS-CoV-2			
Abstract:	Introduction Coronavirus disease 2019 (COVID-19) pandemic has affected the aviation industry. Existing protocols have relied on scientifically questionable evidence and might not lead to the optimal balance between public health safety and airlines' financial viability. Objective To explore the implementation feasibility of Thai Airways International protocol from the perspectives of passengers and aircrews. Design An online questionnaire survey of passengers and an in-depth interview with aircrews. Setting Two randomly selected repatriation flights operated by Thai Airways International using Boeing 777 aircraft (TG476 from Sydney and TG492 from Auckland to Bangkok) Participants 377 Thai passengers and 35 aircrews. Results The mean age of passengers was 28.14 (95%CI 26.72 to 29.55) years old; 57.03% were female. TG492 passengers were mostly students and significantly younger than that of TG476 (p<0.0001) with comparable flying experience (p=0.1192). The average body temperature was 36.52 (95%CI 36.48 to 36.55) degrees Celsius. Passengers estimated average physical distances of 1.59 (95%CI 1.48 to 1.70), 1.41 (95%CI 1.29 to 1.53), and 1.26 (95%CI 1.12 to 1.41) meters at check-in, boarding, and in-flight, respectively. Passengers were checked for body temperature during the flight 1.97 (95%CI 1.77 to 2.18) times on average which is significantly more frequent in longer than shorter flight (p<0.0001). Passengers moved around or went to the toilet during the flight 2.00 (95%CI 1.63 to 2.37) and 2.08 (95%CI 1.73 to 2.43) times which are significantly more frequent in longer than shorter flight (p=0.0186 and 0.0049, respectively). The aircrews were satisfied with the protocol and provided several practical suggestions. Conclusion The protocol was well received by the passengers and aircrews of the repatriation flights with some suggestions for improvement.			
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Opposed Reviewers:				
Response to Reviewers:	Point-by-Point responses to Editor's and Reviewer's Comments:			
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Response: The data has been deidentified and deposited in the UK Data Service. The data was also uploaded to the manuscript submission system while the DOI link is not yet available.

Editor: 3. Thank you for including your competing interests statement; "The authors have declared that no competing interests exist." We note that one or more of the authors are employed by a commercial company: Thai Airways International Public Company Limited. Please provide an amended Funding Statement declaring this commercial affiliation, as well as a statement regarding the Role of Funders in your study. If the funding organization did not play a role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript and only provided financial support in the form of authors' salaries and/or research materials, please review your statements relating to the author contributions, and ensure you have specifically and accurately indicated the role(s) that these authors had in your study. You can update author roles in the Author Contributions section of the online submission form. Please also include the following statement within your amended Funding Statement. "The funder provided support in the form of salaries for authors [insert relevant initials], but did not have any additional role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. The specific roles of these authors are articulated in the 'author contributions' section." If your commercial affiliation did play a role in your study, please state and explain this role within your updated Funding Statement. Please also provide an updated Competing Interests Statement declaring this commercial affiliation along with any other relevant declarations relating to employment, consultancy, patents, products in development, or marketed products, etc. Within your Competing Interests Statement, please confirm that this commercial affiliation does not alter your adherence to all PLOS ONE policies on sharing data and materials by including the following statement: "This does not alter our adherence to PLOS ONE policies on sharing data and materials." (as detailed online in our guide for authors

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Response: The Funding Statement was updated as "Thai Airways International provided support in the form of salaries for author ST, but did not have any additional

	role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. The specific roles of the authors are articulated in the 'author contributions' section." The Competing Interests Stement was updated as "The authors declare that they have no conflicts of interest. The commercial airline affiliation of author ST does not alter our adherence to PLOS ONE policies on sharing data and materials."
	airline protocol during COVID-19 pandemic from Thai airways international to explore the implementation feasibility of airways protocol. They conducted an online questionnaire survey of passengers and in-depth interview with aircrews of two flights and they thought that the protocol was well received by the passengers and aircrews of the repatriation flights. Overall, this article gives a broad interview of the potential flight- level prevent and control transmission of SARS-CoV-2 in flight, but lacks depth.
	Response: Thank you very much for the comments. Although we wish we could conduct a more in-depth study, there had been several situational limitations that prevented us from doing so. We decided to conduct the study as best as possible.
	Reviewer #1: 2. The satisfaction of passengers and crew members should not be taken as the main evaluation parameters of the study. The number of research flights should be increased to improve the reliability of the data.
	Response: The 'satisfaction' of passengers and crew members was not the primary focus of our study. Rather, they were ask to report useful information from their perspectives as shown in Table 2. We wish we could increased the number of research flights as advised.
	Reviewer #1: 3. 124-125 "The overall response rate of this research was 22.50." and "Passengers estimated average physical distances" were the results bias?
	Response: Despite the low response rate, given the situational limitations mentioned above, we believe that the selection bias was only a minor concern in our study. As mentioned in the Discussion section, the responses were from an unbiased seat selection so the findings could be representative of the flights.
	Reviewer #1: 4. The prolonged flight time is bound to increase the number of temperature tests and the number of activities of passengers on the plane, including eating, going to the toilet, etc. If there are confirmed patients on the flight but they are not detected before boarding the aircraft and subject them to the necessary isolation and treatment, these activities must increase the risk of normal passenger infection.
	Response: Thank you very much. We agree with the point raised but our data could not be used for testing the hypothesis.
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Question	Response
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Dear Editor,

We would like to thank you and the reviewer for kind comments and suggestions to our manuscript entitled "Commercial airline protocol during COVID-19 pandemic: An experience of Thai Airways International." Please consider our point-by-point responses as well as manuscript with and wihtout track changes in the journal submission system.

The Funding Statement was updated as "Thai Airways International provided support in the form of salaries for author ST, but did not have any additional role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. The specific roles of the authors are articulated in the 'author contributions' section."

The Competing Interests Stement was updated as "The authors declare that they have no conflicts of interest. The commercial airline affiliation of author ST does not alter our adherence to PLOS ONE policies on sharing data and materials."

We hope that our responses and the revised manuscript are satisfactory. Thank you so much for your kind consideration.

Best Regards, Krit Pongpirul On behalf of the authors

# **1** Commercial airline protocol during COVID-19 pandemic: An

## 2 experience of Thai Airways International

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- 14
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- 17

## 18 Abstract

19 Introduction: Coronavirus disease 2019 (COVID-19) pandemic has affected the aviation industry. Existing

20 protocols have relied on scientifically questionable evidence and might not lead to the optimal balance

- 21 between public health safety and airlines' financial viability.
- 22 Objective: To explore the implementation feasibility of Thai Airways International protocol from the
- 23 perspectives of passengers and aircrews.

24 Design: An online questionnaire survey of passengers and an in-depth interview with aircrews.

25 Setting: Two randomly selected repatriation flights operated by Thai Airways International using Boeing

26 777 aircraft (TG476 from Sydney and TG492 from Auckland to Bangkok)

27 Participants: 377 Thai passengers and 35 aircrews.

28 Results: The mean age of passengers was 28.14 (95%Cl 26.72 to 29.55) years old; 57.03% were female.

29 TG492 passengers were mostly students and significantly younger than that of TG476 (p<0.0001) with

30 comparable flying experience (p=0.1192). The average body temperature was 36.52 (95%Cl 36.48 to

36.55) degrees Celsius. Passengers estimated average physical distances of 1.59 (95%CI 1.48 to 1.70),

32 1.41 (95%Cl 1.29 to 1.53), and 1.26 (95%Cl 1.12 to 1.41) meters at check-in, boarding, and in-flight,

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36 (95%CI 1.73 to 2.43) times which are significantly more frequent in longer than shorter flight (p=0.0186

and 0.0049, respectively). The aircrews were satisfied with the protocol and provided several practical

38 suggestions.

39 Conclusion: The protocol was well received by the passengers and aircrews of the repatriation flights

40 with some suggestions for improvement.

# 41 Introduction

42 Coronavirus disease 2019 (COVID-19) pandemic has affected several industries including 43 aviation. Transmission of the severe acute respiratory syndrome (SARS) associated coronavirus (SARS-CoV) on aircraft was reported—individual with physical proximity to the index symptomatic patient 44 45 (three rows in front) have approximately three times the risk of the passengers who seated elsewhere [1]. Despite many similarities with SARS-CoV, the novel coronavirus (SARS-CoV-2) appears to transmit 46 47 more easily than its predecessor. A recent study reported potential transmission from asymptomatic 48 COVID-19 infected individuals [2], suggesting that symptom-based case detection might be no longer 49 adequate [3]. A commercial airline has begun carrying out serology tests on passengers before 50 departure [4] in addition to temperature screening. 51 Given no specific and robust evidence on the risk of in-flight transmission of the SARS-CoV-2, 52 preventive measures relied on the past experiences; at least 275 options have been proposed to reduce 53 SARS-CoV-2 transmission in five key areas: (1) physical isolation, (2) reducing transmission through 54 contaminated items, (3) enhancing cleaning and hygiene, (4) reducing spread through pets, and (5) 55 restricting disease spread between areas [5]. 56 While several preventive activities have been agreed upon by stakeholders, some measures 57 have raised financial and feasibility concerns to the airline industry. An optimal balance between public 58 health safety and airline financial viability is critical, especially when the airline passenger revenues 59 already dropped by \$314 billion in 2020 [6]. General biosecurity measures such as temperature

60 screening of individuals, minimizing inter-personal contacts during the boarding and deplaning

61 processes, limiting movement within the cabin during flight, increasing frequency and quality of cabin

62 cleaning, and simplifying catering procedures [6] have been implemented at the expense of the aviation

63 industry. The International Air Transport Association (IATA) recently endorsed the mandatory face-

64 coverings for passengers and masks for crew members but opposes onboard social distancing because 65 of the significant loss of revenue [6]. IATA asserted that the risk of infectious disease transmission on 66 board is low even without special measures as suggested by scientifically questionable evidence such as 67 contact tracing for selected flights or informal surveys of major airlines [6]. However, proving the 68 effectiveness of these multi-faceted measures have been difficult. Also, these might not be well 69 perceived or complied by some passengers.

70 Like other national aviation authorities, the Civil Aviation Authority of Thailand (CAAT) has 71 issued a temporary ban on all international flights to Thailand during the COVID-19 pandemic with some 72 exceptions [7]. Several commercial airlines, including Thai Airways International, have been able to 73 operate repatriation flights, organized in coordination with governments to aid citizens stranded abroad. 74 Individuals must fill in and submit the Application for Re-entry Permit to Return into the Kingdom (TM.8) 75 to an immigration officer [8] and the COVID-19 Screening Questionnaire (T.8) to Port Health Officer [9]. 76 The COVID-19 risk score is calculated by using three factors: the number of COVID-19 case in the country 77 of departure, the proportion of seats occupied by the passengers, and flight duration into low, 78 moderate, and high risks (Table 1). Flight without the High-Efficiency Particulate Air (HEPA) filtering 79 system is considered high risk.

## 81 Table 1 COVID-19 Risk Score, The Civil Aviation Authority of Thailand (CAAT)

Score	1	2	3	4	5
Number of Covid-19 Cases in	< 50	50-100	101-500	501-1,000	>1,000
Country of Departure					
Proportion of Seats	< 40	40-80	> 80	-	-
Occupied with Passengers					
(%)					
Flight Duration (hours)	< 4	4-8	> 8	-	-
<b>Risk-based Interventions:</b>					
Low Risk (score 3-4)	Passen	gers: Body	temperature	e check by usir	ng a non-
	contact infrared thermometer before boarding.			ing.	
	Passengers with body temperature higher than 3				nan 37.3
	degree Celsius or upper respiratory tract sympto				nptoms
	(cough, sore throat, running nose, and shortne				
	breath	) will be rea	assessed by I	Port Health Of	ficer if a
	boardii	ng pass cou	ld be given.		
	Crews:	Disposable	e medical or	surgical masks	
	Pilots:	Disposable	medical or s	urgical masks.	
Moderate Risk (score 5-7)	Passen	gers: Body	temperature	e check by usir	ng a non-
	contac	t infrared tl	hermometer	before board	ing and
	in-fligh	t for long-h	iaul (>4 hour	s) flights.	
	Crews:	Disposable	e medical or	surgical masks	
	Pilots:	Disposable	medical or s	urgical masks.	
High Risk (score 8-11 or no	Passen	gers: Body	temperature	e check by usir	ng a non-
HEPA <sup>a</sup> filtering system)	contac	t infrared tl	hermometer	before board	ing and
	in-fligh	t for long-h	iaul (>4 hour	s) flights.	
	Crew: I	V95 or surg	ical masks, g	goggles, and di	sposable
	rubber	gloves.			
	Pilots:	Surgical ma	isks and gog	gles.	

82 <sup>a</sup>High-Efficiency Particulate Air

These repatriation flights offer a wonderful opportunity to gather useful evidence, especially from the passengers' perspective, for commercial airline protocol development and improvement. This study aimed to explore the implementation feasibility of the Thai Airways International protocol from

87 the perspectives of passengers and aircrews.

<sup>83</sup> 

# 89 Methods

90	We conducted an online questionnaire survey of passengers and in-depth interview with
91	aircrews of two randomly selected repatriation flights operated by Thai Airways International: TG476
92	(Sydney-Bangkok; 209 passengers (female 61.24%; adult 92.82%), 3 pilots, and 14 cabin attendants) on
93	April 26 and TG492 (Auckland-Bangkok; 168 passengers (female 51.79%; adult 51.19%), 4 pilots, and 14
94	cabin attendants) on April 27, 2020. The Boeing 777 equipped with 18 seats in the business class and
95	306 seats in the economy class were used for both flights (Fig 1).
96	
97	Fig 1. Passenger Seats Map of TG476 and TG492 Repatriation Flights
98	
99	Passengers were asked to estimate the distance to the nearest individual(s) at check-in,
100	boarding, and inflight as well as their mobility during the flight. Their opinions and willingness-to-pay for
101	six personal in-flight amenities—disposable food containers, bottled water, gloves, tissue paper, mask,
102	face shield—were assessed using a five-point Likert scale (1, strongly disagree to 5, strongly agree) and
103	an open-ended question, respectively. Passenger's confidence in the company before and after the trip
104	was assessed by using a ten-point scale (1, lowest to 10, highest).
105	Descriptive statistics (frequency, mean, and standard deviation) were used for data analysis. The
106	response rate was calculated by using responses from passengers at least 18 years of age. Association
107	between categorical variables was analyzed with the chi-square test. Student's t-test was used to
108	compare interval data between groups as appropriate. Likert scale findings were presented as mean and
109	standard deviation for simplicity but the comparison between groups was performed by using chi-
110	square or Fisher's exact test where appropriate.

## 112 Ethics committee approval

113 This study was approved by the Institutional Review Board of Dhurakij Pundit University.

## 114 Patient and public involvement

115 The inception of this study was from the discussion with the pilots and cabin crews of the Thai 116 Airways International. They agreed with the simple anonymous survey of passengers and in-depth 117 interviews with aircrews.

## 118 **Results**

119 Thirty-seven and forty-one passengers of TG476 and TG492 responded to the survey,

respectively. The overall response rate was 22.50% with statistically significant differences between the

121 two flights (18.04% vs 32.56%, respectively; p=0.007). Mean age and gender distribution of respondents

and non-respondents were not statistically different (p=0.6566 and 0.156, respectively).

123 The mean age of passengers was 28.14±13.94 years old and 57.03% were female. TG492

passengers were mostly students and significantly younger than that of TG476 (p<0.0001) although both

groups have comparable flying experience (p=0.1192) (Table 2, Fig 1). The average body temperature

126 was 36.52±0.34 degrees Celsius.

	Overall	TG476	TG492	p-value
Route		Sydney-Bangkok	Auckland-Bangkok	
Flight Distance (kilometers)		7,523	9,566	
Flight Duration (hours)		9:25	11:50	
Response Rates				
- Overall	78/377	37/209	41/168	0.1100
- Age >= 18	63/280	35/194	28/86	0.0070
Age <sup>a</sup>	28.14±13.94	32.69±13.65	22.53±12.17	<0.0001
Female	57.03%	61.24%	51.79%	0.0650
Student	50.93%	34.93%	70.83%	<0.0001
Flying Experience (times in 2019) <sup>a</sup>	3.79±6.07	2.64±2.54	4.80±7.89	0.1192
Body Temperature (degree	36.52±0.34	36.61±0.34	36.40±0.30	<0.0001
Celsius) <sup>a</sup>				
Physical Distance (meters) <sup>a</sup>				
- Check-in	1.59±0.48	1.57±0.36	1.61±0.58	0.7020
- Boarding	1.41±0.52	1.42±0.28	1.40±0.68	0.8507
- In-flight	1.26±0.65	1.27±0.28	1.26±0.86	0.9239
In-flight Body Temperature	1.97±0.91	1.32±0.53	2.56±0.78	<0.0001
Checked (times) <sup>a</sup>				
In-flight Mobility (times) <sup>a</sup>				
- Move Around	2.00±1.65	1.54±1.41	2.41±1.76	0.0186
- To Toilet	2.08±1.54	1.57±1.30	2.54±1.61	0.0049
In-flight Personal Amenities <sup>a</sup>				
- Disposable Food Container	4.59±0.78	4.54±0.87	4.63±0.70	0.6000
- Bottled Water	4.77±0.64	4.73±0.77	4.80±0.51	0.6095
- Gloves	4.46±1.02	4.46±1.10	4.46±0.95	0.9864
- Tissue Paper	4.68±0.67	4.65±0.75	4.71±0.60	0.7038
- Mask	4.74±0.69	4.65±0.89	4.83±0.44	0.2523
- Face Shield	4.54±0.88	4.46±1.04	4.61±0.70	0.4540
Willingness-to-Pay for In-flight				
- Disposable Food Container	60 62+82 15	18 80+60 05	71 22+01 26	0 2221
- Disposable Food Container	32 71+65 /1	48.89±09.95	/1.22-91.30	0.2331
- Gloves	27 42+59 56	14 70+18 53	38 90+78 96	0.0730
- Tissue Paner	21 42+30 00	12 57+13 09	29 41+37 95	0.0723
- Mask	34.04+62.59	24.03+36.40	43.09+78 56	0.1810
- Face Shield	44.04±45.94	29.97±40.67	56.73±47.19	0.0093
Confidence in Thai Airways <sup>a</sup>				
- Before	7.64±2.47	7.62±2.49	7.66±2.48	
- After	8.10±2.49	8.19±2.46	8.02±2.54	
- p-value	0.0001	0.0032	0.0144	

## 128 Table 2 Characteristics and Experience of Passengers in Two Thai Airways Repatriation Flights

<sup>a</sup>Mean±SD; THB, Thai Baht (US\$1 = THB32.45 as of April 26, 2020)

130

131 Passengers estimated average physical distances of 1.59±0.48, 1.41±0.52, and 1.26±0.65 meters

132 at check-in, boarding, and in-flight, respectively. The physical distances at all stages were not different

between the two flights. Passengers were checked for body temperature during the flight 1.97±0.91
times on average which is significantly more frequent in longer than shorter flight (p<0.0001). Likewise,</li>
the passengers moved around or went to the toilet during the flight 2.00±1.65 and 2.08±1.54 times
which are significantly more frequent in longer than shorter flight (p=0.0186 and 0.0049, respectively).
The passengers agreed with the importance of in-flight personal amenities but were willing to pay for
them at varying prices. The confidence in the airline company was statistically significantly increased
from 7.64±2.47 before the trip to 8.10±2.49 after the trip (p=0.0001).

140 The aircrews were satisfied with the protocol and provided several practical suggestions. Despite the return-to-work intention, they had expressed concerns regarding occupational exposure of 141 142 themselves and their family members. These concerns seemed to be alleviated after the actual 143 experiences working in the repatriation flights. Physical distancing at approximately 1.5 to 2.0 meters 144 was more practical at the check-in counter, pre-boarding area, and boarding line than during the flight. 145 The cabin areas were divided by disposable curtains into five designated areas. 'Clean area' was 146 located at the frontmost of the plane, in which only crews with PPE were allowed. 'Buffer zone' was 147 assigned as a dressing area for crews. In the 'passenger sitting area', the initial CAAT requirement to set 148 at least one meter between any two passengers was not feasible for the present seating layout so the 149 repatriation flights asked and received permission from CAAT so that any adjacent seat is empty except 150 for the declared family members. This was also done in the 'quarantine area' (the last three rows), 151 which was for either passengers or crews with unanticipated symptoms just identified onboard. In that 152 case, one cabin crew with PPE will be assigned for the service in the quarantine area and could not be 153 close to the other crews within two meters. 'Lavatories' at the front of the plane were allowed only for 154 crews. Magazines, newspapers, and unnecessary documents were removed. 155 Cabin crews got dressed in personal protective equipment (PPE) in the buffer zone with no

difficulty. However, they reported several occasions in which the crews with PPE crossed paths with the

157 less protected crews. Passengers received surgical mask and face-shield and cleaned their hands with 158 alcohol gel before boarding; however, this approach was not practical for several passengers who had 159 many carry-ons. Before providing the in-flight services, the cabin crews and passengers had to stay only 160 in the assigned zones and minimize their movements. Prepackaged food in disposable containers, 161 utensils, and bottled water were given to individual passengers. The food service was provided at 162 different times, if possible, to minimize the chance of simultaneous mask removal by nearby passengers. 163 Passengers were asked to use the provided alcohol gel to clean their hands before and after the meal. 164 The passengers were asked to drop the garbage to the garbage cart by themselves or on the service tray 165 to minimize physical contact with the cabin crew. The lavatory was disinfected every use. 166 During the landing, the cabin crews announced that the passengers remain seated and keep the

physical distancing while disembarkation. After landing, the cabin crews noticed several passengers attempted to move out too early which might fail the physical distancing principle, so they decided to allow the passengers to stand and disembark on a row-by-row basis. Aircrews moved to buffer zone and take off the PPE before the cleaning staff moved in for aircraft disinfection. All passengers in both flights tested reverse-transcription—polymerase-chain-reaction (RT-PCR) for COVID-19 and were quarantined at a government-provided hotel in Bangkok for 14 days.

## 173 **Discussion**

The aviation industry has been greatly affected by the COVID-19 pandemic. Several preventive measures have been proposed [5] and some were implemented but might not ensure the optimal balance between public health risk minimization and airline financial viability. While the diagnostics industry has advanced laboratories and healthcare industry has hospital facilities for producing scientifically robust evidence, the aviation industry has a unique and dynamic context that might not be appropriate for evidence generation. The repatriation flights that received permission to operate during

the COVID-19 pandemic have provided a partially controlled setting to collect useful data from
 passengers' perspective and gather feedbacks from aircrews to assess the implementation feasibility of
 the mandatory protocol.

The protocol was well received by the passengers and aircrews. Physical distances seemed to be context-sensitive, as suggested by the varying physical distances between the check-in, boarding, and inflight areas. Estimated physical distance reported by passengers might not be accurate but the data could reflect the subjective perception of passengers which is influential for business.

Some regulations might not have adequate detail so the inputs from the real experiences are essential. For instance, in-flight body temperature check was required for long-haul moderate- and highrisk flights but no frequency was specified. Passengers of the repatriation flights in this study not only agreed with the temperature check but also remained aware that they were approached for a body temperature check.

This study has some limitations. First, the response rates of this voluntary questionnaire survey were low; however, the responses were from an unbiased seat selection and could be representative of the flights. Second, the self-reported data relied on passengers' perception and might not be accurate to be used as a reference for real practice. Third, the nature of Thai passengers might not be exactly like that of other ethnic origins.

#### 197 Summary Box

Several preventive measures for in-flight transmission of the SARS-CoV-2 has relied on past
 experiences and raised financial and feasibility concerns to the airline industry.

- Evidence on the implementation feasibility of commercial airline infection control protocol,
- 201 especially from the perspectives of passengers and aircrews, has been lacking.
- Our study suggests that the passengers reported varying degrees of physical distancing at check-
- in, boarding, and in-flight and that the in-flight body temperature check was possible.

• The Thai Airways protocol was well received by the passengers and aircrews.

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# 208 Competing Interests Statement

- 209 The authors declare that they have no conflicts of interest. The commercial airline affiliation of
- author ST does not alter our adherence to PLOS ONE policies on sharing data and materials.

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- 215 contributions' section.

## 216 Author Contributions

- 217 Conceptualization: KP, KK, ST; Data Curation: KK, KC, ST; Formal Analysis: KP, KK; Investigation:
- 218 KP, KK, KC; Methodology: KP; Project Administration: KP; Supervision: ST; Validation: KK, KC, ST;
- 219 Visualisation: KC; Writing Original Draft: KP, KC, ST; Writing Review & Editing: KP, KK, KC, ST

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Female Respondents

Female Passengers

Male Respondents

Male Passengers

Data File in Stata Format

Click here to access/download **Supporting Information** TG Repatriation Flights during Covid-19 Deidentified.dta

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- 29 Word Counts: 1,893 Words (Text); 270 Words (Abstract)
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### 32 Abstract

- 33 Introduction: Coronavirus disease 2019 (COVID-19) pandemic has affected the aviation industry. Existing
- 34 protocols have relied on scientifically questionable evidence and might not lead to the optimal balance
- 35 between public health safety and airlines' financial viability.
- 36 Objective: To explore the implementation feasibility of Thai Airways International protocol from the
- 37 perspectives of passengers and aircrews.
- 38 Design: An online questionnaire survey of passengers and an in-depth interview with aircrews.
- 39 Setting: Two randomly selected repatriation flights operated by Thai Airways International using Boeing
- 40 777 aircraft (TG476 from Sydney and TG492 from Auckland to Bangkok)
- 41 Participants: 377 Thai passengers and 35 aircrews.
- 42 Results: The mean age of passengers was 28.14 (95%CI 26.72 to 29.55) years old; 57.03% were female.
- 43 TG492 passengers were mostly students and significantly younger than that of TG476 (p<0.0001) with
- 44 comparable flying experience (p=0.1192). The average body temperature was 36.52 (95%CI 36.48 to
- 45 36.55) degrees Celsius. Passengers estimated average physical distances of 1.59 (95%CI 1.48 to 1.70),
- 46 1.41 (95%CI 1.29 to 1.53), and 1.26 (95%CI 1.12 to 1.41) meters at check-in, boarding, and in-flight,
- 47 respectively. Passengers were checked for body temperature during the flight 1.97 (95%Cl 1.77 to 2.18)
- 48 times on average which is significantly more frequent in longer than shorter flight (p<0.0001).
- 49 Passengers moved around or went to the toilet during the flight 2.00 (95%Cl 1.63 to 2.37) and 2.08
- 50 (95%CI 1.73 to 2.43) times which are significantly more frequent in longer than shorter flight (p=0.0186
- and 0.0049, respectively). The aircrews were satisfied with the protocol and provided several practical
- 52 suggestions.
- 53 Conclusion: The protocol was well received by the passengers and aircrews of the repatriation flights
- 54 with some suggestions for improvement.

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## 56 Introduction

Coronavirus disease 2019 (COVID-19) pandemic has affected several industries including
aviation. Transmission of the severe acute respiratory syndrome (SARS) associated coronavirus (SARS-
CoV) on aircraft was reported—individual with physical proximity to the index symptomatic patient
(three rows in front) have approximately three times the risk of the passengers who seated elsewhere
[1]. Despite many similarities with SARS-CoV, the novel coronavirus (SARS-CoV-2) appears to transmit
more easily than its predecessor. A recent study reported potential transmission from asymptomatic
COVID-19 infected individuals [2], suggesting that symptom-based case detection might be no longer
adequate [3]. A commercial airline has begun carrying out serology tests on passengers before
departure [4] in addition to temperature screening.
Given no specific and robust evidence on the risk of in-flight transmission of the SARS-CoV-2,
preventive measures relied on the past experiences; at least 275 options have been proposed to reduce
SARS-CoV-2 transmission in five key areas: (1) physical isolation, (2) reducing transmission through
contaminated items, (3) enhancing cleaning and hygiene, (4) reducing spread through pets, and (5)
restricting disease spread between areas [5].
While several preventive activities have been agreed upon by stakeholders, some measures
have raised financial and feasibility concerns to the airline industry. An optimal balance between public
health safety and airline financial viability is critical, especially when the airline passenger revenues
already dropped by \$314 billion in 2020 [6]. General biosecurity measures such as temperature
screening of individuals, minimizing inter-personal contacts during the boarding and deplaning
processes, limiting movement within the cabin during flight, increasing frequency and quality of cabin
cleaning, and simplifying catering procedures [6] have been implemented at the expense of the aviation
industry. The International Air Transport Association (IATA) recently endorsed the mandatory face-

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79	coverings for passengers and masks for crew members but opposes onboard social distancing because
80	of the significant loss of revenue [6]. IATA asserted that the risk of infectious disease transmission on
81	board is low even without special measures as suggested by scientifically questionable evidence such as
82	contact tracing for selected flights or informal surveys of major airlines [6]. However, proving the
83	effectiveness of these multi-faceted measures have been difficult. Also, these might not be well
84	perceived or complied by some passengers.
85	Like other national aviation authorities, the Civil Aviation Authority of Thailand (CAAT) has
86	issued a temporary ban on all international flights to Thailand during the COVID-19 pandemic with some
87	exceptions [7]. Several commercial airlines, including Thai Airways International, have been able to
88	operate repatriation flights, organized in coordination with governments to aid citizens stranded abroad.
89	Individuals must fill in and submit the Application for Re-entry Permit to Return into the Kingdom (TM.8)
90	to an immigration officer [8] and the COVID-19 Screening Questionnaire (T.8) to Port Health Officer [9].
91	The COVID-19 risk score is calculated by using three factors: the number of COVID-19 case in the country
92	of departure, the proportion of seats occupied by the passengers, and flight duration into low,
93	moderate, and high risks (Table 1). Flight without the High-Efficiency Particulate Air (HEPA) filtering
94	system is considered high risk.
95	

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Number of Covid-19 Cases in	< 50	50-100	101-500	501-1,000	>1,000	•	Formattade Fonte Dald
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Proportion of Seats	< 40	40-80	> 80	-	-	•	Formatted: Line spacing: single
Occupied with Passengers (%)							Formatted: Font: Bold
Flight Duration (hours)	< 4	4-8	> 8	-	-	•	Formatted: Line spacing: single
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	breath) will be reassessed by Port Health Officer if a boarding pass could be given. Crews: Disposable medical or surgical masks.					N	Formatted: Line spacing: single
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High Risk (score 8-11 or no	Passengers: Body temperature check by using a non-				ng a non-		Formatted: Font: Bold
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	rubber gloves. Pilots: Surgical masks and goggles.			, , , , , , , , , , , , , , , , , , ,	Formatted: Font: Bold		
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102 study aimed to explore the implementation feasibility of the Thai Airways International protocol from

103 the perspectives of passengers and aircrews.

105	Methods	Formatted: Font: 18 pt
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106	We conducted an online questionnaire survey of passengers and in-depth interview with	Formatted: Indent: First line: 0.5"
107	aircrews of two randomly selected repatriation flights operated by Thai Airways International: TG476	
108	(Sydney-Bangkok; 209 passengers (female 61.24%; adult 92.82%), 3 pilots, and 14 cabin attendants) on	
109	April 26 and TG492 (Auckland-Bangkok; 168 passengers (female 51.79%; adult 51.19%), 4 pilots, and 14	
110	cabin attendants) on April 27, 2020. The Boeing 777 equipped with 18 seats in the business class and	
111	306 seats in the economy class were used for both flights (Figure 1).	
112		
113	Figure 1. Passenger Seats Map of TG476 and TG492 Repatriation Flights	Formatted: Font: Bold
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115	Passengers were asked to estimate the distance to the nearest individual(s) at check-in,	Formatted: Indent: First line: 0.5"
116	boarding, and inflight as well as their mobility during the flight. Their opinions and willingness-to-pay for	
117	six personal in-flight amenities—disposable food containers, bottled water, gloves, tissue paper, mask,	
118	face shield—were assessed using a five-point Likert scale (1, strongly disagree to 5, strongly agree) and	
119	an open-ended question, respectively. Passenger's confidence in the company before and after the trip	
120	was assessed by using a ten-point scale (1, lowest to 10, highest).	
121	Descriptive statistics (frequency, mean, and standard deviation) were used for data analysis. The	
122	response rate was calculated by using responses from passengers at least 18 years of age. Association	
123	between categorical variables was analyzed with the chi-square test. Student's t-test was used to	
124	compare interval data between groups as appropriate. Likert scale findings were presented as mean and	
125	standard deviation for simplicity but the comparison between groups was performed by using chi-	
126	square or Fisher's exact test where appropriate.	
127		

128	Ethics <u>c</u> ommittee <u>a</u> Approval		Formatted: Font: 16 pt, Bold, Not Italic
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129	This study was approved by the Institutional Review Board of Dhurakij Pundit University.		Formatted: Font: 16 pt, Bold, Not Italic
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130	Patient and pPublic involvement	(	Formatted: Font: 16 pt, Bold, Not Italic
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131	The inception of this study was from the discussion with the pilots and cabin crews of the Thai $~$ ${ ilde{}}$		Formatted: Font: 16 pt, Bold, Not Italic
132	Airways International. They agreed with the simple anonymous survey of passengers and in-depth	1	Formatted: Indent: First line: 0.5"
133	interviews with aircrews.		
134	Results		Formatted: Font: 18 pt
135	Thirty-seven and forty-one passengers of TG476 and TG492 responded to the survey,	(	Formatted: Indent: First line: 0.5"
136	respectively. The overall response rate was 22.50% with statistically significant differences between the		
137	two flights (18.04% vs 32.56%, respectively; p=0.007). Mean age and gender distribution of respondents		
138	and non-respondents were not statistically different (p=0.6566 and 0.156, respectively).		
139	The mean age of passengers was 28.14 $\pm$ 13.94 years old and 57.03% were female. TG492		
140	passengers were mostly students and significantly younger than that of TG476 (p<0.0001) although both		
141	groups have comparable flying experience (p=0.1192) (Table 2, Fig <del>ure</del> 1). The average body temperature		
142	was 36.52±0.34 degrees Celsius.		
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	Overall	TG476	TG492	p-value	-
Route		Sydney-Bangkok	Auckland-Bangkok		
Flight Distance (kilometers)		7,523	9,566		•
Flight Duration (hours)		9:25	11:50		•
Response Rates					•
- Overall	78/377	37/209	41/168	0.1100	
- Age >= 18	63/280	35/194	28/86	0.0070	
Ageª	28.14±13.94	32.69±13.65	22.53±12.17	< 0.0001	•
Female	57.03%	61.24%	51.79%	0.0650	•
Student	50.93%	34.93%	70.83%	< 0.0001	•
Flying Experience (times in	3.79±6.07	2.64±2.54	4.80±7.89	0.1192	•
2019)ª					
Body Temperature (degree	36.52±0.34	36.61±0.34	36.40±0.30	< 0.0001	•
<u>Celsius)<sup>a</sup></u>					
Physical Distance (meters)					•
- Check-in	1.59±0.48	1.57±0.36	1.61±0.58	0.7020	
- Boarding	1.41±0.52	1.42±0.28	1.40±0.68	0.8507	
- In-flight	1.26±0.65	1.27±0.28	1.26±0.86	0.9239	
In-flight Body Temperature	1.97±0.91	1.32±0.53	2.56±0.78	< 0.0001	•
Checked (times) <sup>a</sup>					
In-flight Mobility (times)					•
- Move Around	2.00±1.65	1.54±1.41	2.41±1.76	0.0186	
- To Toilet	2.08±1.54	1.57±1.30	2.54±1.61	0.0049	
In-flight Personal Amenities					-
- Disposable Food Container	4.59±0.78	4.54±0.87	4.63±0.70	0.6000	
- Bottled Water	4.77±0.64	4.73±0.77	4.80±0.51	0.6095	
- Gloves	4.46±1.02	4.46±1.10	4.46±0.95	0.9864	
- Tissue Paper	4.68±0.67	4.65±0.75	4.71±0.60	0.7038	
- Mask	4.74±0.69	4.65±0.89	4.83±0.44	0.2523	
- Face Shield	4.54±0.88	4.46±1.04	4.61±0.70	0.4540	
Willingness-to-Pay for In-flight					•
Personal Amenities (THB)					
- Disposable Food Container	60.63±82.15	48.89±69.95	71.22±91.36	0.2331	
- Bottled Water	32.71±65.41	19.05±20.75	45.02±86.72	0.0798	
- Gloves	27.42±59.56	14.70±18.53	38.90±78.96	0.0729	
- Tissue Paper	21.42±30.00	12.57±13.09	29.41±37.95	0.0123	
- Mask	34.04±62.59	24.03±36.40	43.09±78.56	0.1810	
- Face Shield	44.04±45.94	29.97±40.67	56.73±47.19	0.0093	
Confidence in Thai Airways					•
- Before	7.64±2.47	7.62±2.49	7.66±2.48		
- After	8.10±2.49	8.19±2.46	8.02±2.54		
- p-value	0.0001	0.0032	0.0144		

#### 145 Table 2 Characteristics and Experience of Passengers in Two Thai Airways Repatriation Flights

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Passengers estimated average physical distances of 1.59±0.48, 1.41±0.52, and 1.26±0.65 meters

149 at check-in, boarding, and in-flight, respectively. The physical distances at all stages were not different

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<ul> <li>times on average which is significantly more frequent in longer than shorter flight (p&lt;0.0001). Like</li> <li>the passengers moved around or went to the toilet during the flight 2.00±1.65 and 2.08±1.54 time</li> <li>which are significantly more frequent in longer than shorter flight (p=0.0186 and 0.0049, respective</li> <li>The passengers agreed with the importance of in-flight personal amenities but were willing to pay</li> <li>them at varying prices. The confidence in the airline company was statistically significantly increas</li> <li>from 7.64±2.47 before the trip to 8.10±2.49 after the trip (p=0.0001).</li> <li>The aircrews were satisfied with the protocol and provided several practical suggestions.</li> <li>Despite the return-to-work intention, they had expressed concerns regarding occupational exposure</li> </ul>	wise, s ely). for ed re of
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157The aircrews were satisfied with the protocol and provided several practical suggestions.158Despite the return-to-work intention, they had expressed concerns regarding occupational exposu-	re of
158 Despite the return-to-work intention, they had expressed concerns regarding occupational exposu	re of
themselves and their family members. These concerns seemed to be alleviated after the actual	
160 experiences working in the repatriation flights. Physical distancing at approximately 1.5 to 2.0 met	ers
161 was more practical at the check-in counter, pre-boarding area, and boarding line than during the f	ight.
162 The cabin areas were divided by disposable curtains into five designated areas. 'Clean area	' was
located at the frontmost of the plane, in which only crews with PPE were allowed. 'Buffer zone' w	S
assigned as a dressing area for crews. In the 'passenger sitting area', the initial CAAT requirement	o set
at least one meter between any two passengers was not feasible for the present seating layout so	the
repatriation flights asked and received permission from CAAT so that any adjacent seat is empty e	cept
for the declared family members. This was also done in the 'quarantine area' (the last three rows)	
168 which was for either passengers or crews with unanticipated symptoms just identified onboard. Ir	that
169 case, one cabin crew with PPE will be assigned for the service in the quarantine area and could no	be
close to the other crews within two meters. 'Lavatories' at the front of the plane were allowed on	y for
171 crews. Magazines, newspapers, and unnecessary documents were removed.	
172 Cabin crews got dressed in personal protective equipment (PPE) in the buffer zone with no	,

173 difficulty. However, they reported several occasions in which the crews with PPE crossed paths with the

174	less protected crews. Passengers received surgical mask and face-shield and cleaned their hands with	
175	alcohol gel before boarding; however, this approach was not practical for several passengers who had	
176	many carry-ons. Before providing the in-flight services, the cabin crews and passengers had to stay only	
177	in the assigned zones and minimize their movements. Prepackaged food in disposable containers,	
178	utensils, and bottled water were given to individual passengers. The food service was provided at	
179	different times, if possible, to minimize the chance of simultaneous mask removal by nearby passengers.	
180	Passengers were asked to use the provided alcohol gel to clean their hands before and after the meal.	
181	The passengers were asked to drop the garbage to the garbage cart by themselves or on the service tray	
182	to minimize physical contact with the cabin crew. The lavatory was disinfected every use.	
183	During the landing, the cabin crews announced that the passengers remain seated and keep the	
184	physical distancing while disembarkation. After landing, the cabin crews noticed several passengers	
185	attempted to move out too early which might fail the physical distancing principle, so they decided to	
186	allow the passengers to stand and disembark on a row-by-row basis. Aircrews moved to buffer zone and	
187	take off the PPE before the cleaning staff moved in for aircraft disinfection. All passengers in both flights	
188	tested reverse-transcription—polymerase-chain-reaction (RT-PCR) for COVID-19 and were quarantined	
189	at a government-provided hotel in Bangkok for 14 days.	
190	Discussion	
101	The eviction inductor has been greatly effected by the COVID 10 pendemic. Several proventive	
191	The aviation industry has been greatly affected by the COVID-19 pandemic. Several preventive	
192	measures have been proposed [5] and some were implemented but might not ensure the optimal	
193	balance between public health risk minimization and airline financial viability. While the diagnostics	

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- 194 industry has advanced laboratories and healthcare industry has hospital facilities for producing
- scientifically robust evidence, the aviation industry has a unique and dynamic context that might not be
- 196 appropriate for evidence generation. The repatriation flights that received permission to operate during

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197	the COVID-19 pandemic have provided a partially controlled setting to collect useful data from	
198	passengers' perspective and gather feedbacks from aircrews to assess the implementation feasibility of	
199	the mandatory protocol.	
200	The protocol was well received by the passengers and aircrews. Physical distances seemed to be	
201	context-sensitive, as suggested by the varying physical distances between the check-in, boarding, and in-	
202	flight areas. Estimated physical distance reported by passengers might not be accurate but the data	
203	could reflect the subjective perception of passengers which is influential for business.	
204	Some regulations might not have adequate detail so the inputs from the real experiences are	
205	essential. For instance, in-flight body temperature check was required for long-haul moderate- and high-	
206	risk flights but no frequency was specified. Passengers of the repatriation flights in this study not only	
207	agreed with the temperature check but also remained aware that they were approached for a body	
208	temperature check.	
209	This study has some limitations. First, the response rates of this voluntary questionnaire survey	
210	were low; however, the responses were from an unbiased seat selection and could be representative of	
211	the flights. Second, the self-reported data relied on passengers' perception and might not be accurate to	
212	be used as a reference for real practice. Third, the nature of Thai passengers might not be exactly like	
213	that of other ethnic origins.	
214	Summary Box	
215	Several preventive measures for in-flight transmission of the SARS-CoV-2 has relied on past	
216	experiences and raised financial and feasibility concerns to the airline industry.	
217	• Evidence on the implementation feasibility of commercial airline infection control protocol,	
218	especially from the perspectives of passengers and aircrews, has been lacking.	
219	Our study suggests that the passengers reported varying degrees of physical distancing at check-	
220	in, boarding, and in-flight and that the in-flight body temperature check was possible.	

221	The Thai Airways protocol was well received by the passengers and aircrews.	
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223 224	The authors would like to thank Dr. Kornprom Saengaram and Vongsa Laovoravit for their kind 🔸 advice.	 Formatted: Indent: First line: 0.5"
225	Declaration of Conflictsmpeting of Interests Statement	Formatted: Font: 18 pt
226	The authors declare that they have no conflicts of interest. The commercial airline affiliation of	Formatted: Indent: First line: 0.5"
227	author ST does not alter our adherence to PLOS ONE policies on sharing data and materials.	
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230	have any additional role in the study design, data collection and analysis, decision to publish, or	
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232	contributions' section.	
233	<u>Author</u> Contribut <del>orsh</del> i <u>on</u> ps	Formatted: Font: 18 pt
234	Conceptualization: KP, KK, ST; Data Curation: KK, KC, ST; Formal Analysis: KP, KK; Investigation: 🔸	 Formatted: Indent: First line: 0.5"
235	KP, KK, KC; Methodology: KP; Project Administration: KP; Supervision: ST; Validation: KK, KC, ST;	
236	Visualisation: KC; Writing Original Draft: KP, KC, ST; Writing Review & Editing: KP, KK, KC, ST	
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