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Editorial

Plasticosis: an Emerging Non-infectious Disease

Alden Henderson, Chief Editor

Emerging and re-emerging infectious diseases have been a popular topic in scientific journals because of their novelty and impact on human health. Most of these diseases are a result of viruses spilling over from wildlife to humans. Recently, there have been reports of whales beaching and fish being killed due to an unknown cause. In many of these events, plastic items have been found in the animal's gastrointestinal track. Biologists suspect that ingestion of plastic caused these deaths. An article in the Journal of Hazardous Materials gave a name to this condition: plasticosis.[1] This article is the first recorded instance of plastic-induced fibrosis in wild animals as an emerging non-infectious disease.

The authors examined the digestive track of seabirds in Australia's Lord Howe Island. They reported scarring of the birds' digestive tracks and the more plastic the birds ingested, the more scarring occurred. They called the disease fibrotic disease plasticosis caused by ingesting plastic in the environment. The plastic causes inflammation of the digestive tract and persistent inflammation may cause scarring. This affects the bird's digestion, growth, and survival. While the birds look healthy their digestive system is damaged.

The term plasticosis was previously used to describe the breakdown of plastic in joint replacements. Its use was not common. The researchers brought back the name because of its similarity to other fibrotic diseases caused by inorganic materials such as silica and asbestos.

Wildlife health has been a sentinel event for human health. Examples of emerging diseases among animals were pigs and Nipah virus disease, crows and West Nile virus, and Hendra virus and horses. All there were due to infectious agents. Plasticosis is caused by a non-infectious agent and becomes one of the first non-infectious emerging disease. As with infectious emerging diseases crossing over pathogens from animals to humans, plasticosis may jump from the environment to humans.

Reference:

1. Charlton-Howard HS, Bond AL, Rivers-Auty J, Lavers JL. 'Plasticosis': Characterising macro- and microplastic-associated fibrosis in seabird tissues. J Hazard Mater. 2023 Feb 26;450:131090. doi:10.1016/j.jhazmat.2023.131090.

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Peripheral Neuropathy Outbreaks in Bhutan, 2020–2021

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Abstract

Thiamine (vitamin B1) deficiency can cause beriberi leading to cardiac involvement or, more commonly, peripheral neuropathy. Common causes of thiamine deficiency are alcohol use, maternal thiamine deficiency, poor dietary diversity, unhygienic food preparation, and unsafe cooking practices. This report presents an analysis of suspected peripheral neuropathy outbreaks recorded at the Royal Centre for Disease Control between 2020 and 2021. The suspected outbreaks were reported from schools and monastic institutes with the main complaints of numbness and swelling of lower limbs. Three of the four events were confirmed due to thiamine deficiency by laboratory analysis. Of 34 samples tested, 27 (79%) had thiamine deficiency, defined as a thiamine diphosphate (ThDP) level <75.0 nmol/L. The mean ThDP level was 56.5 nmol/L. There were no statistically significant differences in the average ThDP level among the patients of different age groups. Given the fact that micronutrient deficiency was established as the cause of the current peripheral neuropathy outbreaks, we recommend that the supply of fortified rice across both government and private institutes in the country be initiated. Holistic approaches should be implemented to reduce the burden of micronutrient deficiencies in the country.

Keywords: beriberi, Bhutan, peripheral neuropathy, thiamine, vitamin

Introduction

Thiamine (vitamin B1) plays an important role in energy metabolism and is naturally soluble in water.[1] Beriberi is a condition related to severe thiamine deficiency due to inadequate content in daily diet. Thiamine deficiency can develop within 2–3 months of inadequate thiamine consumption leading to cardiac involvement or, more commonly, peripheral neuropathy (PN) and, if not treated in time, can be fatal.[2] In patients with Wernicke encephalopathy, thiamine deficiency causes irreversible neurologic damage in about 85% of cases.[3] Alcohol use is the most common risk factor for thiamine deficiency among adults. Maternal thiamine deficiency, insufficient thiamine in breast milk, poor dietary diversity, food preparation and cooking practices are other causes in infants and young adults.[4]

Common sources of thiamine are meat products, particularly pork, and whole grains, yeast, and legumes.[5] The recommended nutrient intake (RNI) of thiamine is 1.2 milligrams per day (mg/day) for men and 1.1 mg/day for women, and for pregnant and lactating women, the RNI levels are 1.4 and 1.5 mg/day, respectively.[6] The biologically active form of thiamine, known as thiamine diphosphate (ThDP), is required as a cofactor for the functions of enzymatic pathways.[7] The two biomarkers for assessing thiamine status in the body are erythrocyte transketolase assay and measuring thiamine metabolites.[6] Diagnostic cut-off values for measuring whole blood total ThDP range from 75–180 nanomoles per litre (nmol/L).[8]

Thiamine deficiency was recently recognized as a public health concern in Southeast Asian countries.[9] Thiamine deficiency cases have previously been reported in Bhutan affecting young school-going students with loss of productive time and a few reported deaths.[10,11] Pradhan et al., (2021) found that infantile beriberi was the main cause of infant mortality (>70%) in Bhutan.[12] In 2017 several sporadic

thiamine deficiency outbreaks were recorded in Bhutan among school children, thus fortified rice supplementation was initiated. Several PN outbreaks were reported from the institutes where fortified rice is not provided. We aim to present results of our investigation of suspected outbreaks of PN in the country between 2020 and 2021 for better public health interventions and to prevent future disease outbreaks.

Methods

Data on suspected outbreaks of PN were extracted from the National Early Warning and Response Alert Surveillance System, maintained by the Royal Centre for Disease Control (RCDC). The laboratory analysis report was retrieved from the Food and Nutrition Laboratory. As shown in Table 1, four events of suspected PN outbreaks from four separate districts were reported during the study period.

A PN outbreak is suspected by a physician when patients visit a health center with chief complaints of numbness, weakness and tingling sensations of the lower limbs. Medical teams from the field (hospitals and primary health centers) upon suspicion of PN reported the outbreaks through the National Early Warning and Response Alert Surveillance System. The surveillance unit from RCDC confirmed the outbreak and initiated the outbreak investigation.[13,14]

Whole blood samples were collected in ethylenediaminetetraacetic acid (EDTA) vacutainers from outbreak investigation sites and were immediately wrapped with aluminum foil to prevent deterioration due to exposure to light. The samples were shipped to RCDC immediately maintaining a cold chain at 2–8 °C. All samples were immediately stored at –40 °C until tested.

The blood samples were collected and prepared as per the existing standard operating procedure of the Food and Nutrition Laboratory, RCDC. Briefly, the samples were thawed quickly and homogenized. A 200 µl vial of whole blood was mixed with a 100 µl internal solution followed by the addition of a 300 µl precipitation reagent and centrifuged at 14,000 rotations per minute for 5 minutes. In a light-protected vial, 250 µl neutralization reagent, 100 µl derivatization reagent, and 250 µl supernatant were mixed and incubated at 60 °C for 25 minutes. The samples were cooled to room temperature and then centrifuged at 14,000 rotations per minute for 2 minutes. The supernatant was filtered using a 0.2-micron syringe filter into the light-protected sample vial and stored at 2–4 °C. The reagents kits and consumables for the determination of thiamine and the high-performance liquid chromatography (HPLC) column were purchased from Chromsystem, Germany. HPLC with a fluorescent detector from Agilent Technologies, Inc. was used for the analysis of samples as per the method mentioned by Korner et al., (2009).[15] The mobile phase was delivered at a flow rate of 1.0 ml/min, the speed at which the detector was set; excitation at 375 nanometers and emission at 430 nanometers. Instrument control and data acquisition were performed using Chromeleon software.

For the quality control of the test results, the control samples level 1 and level 2 were purchased from Chromsystem. The lyophilized sample was prepared using HPLC grade water. Control samples were run for three times prior to testing. Prepared quality control samples were stored at –20 °C.

Data were imported into SPSS software for analysis. Data were presented as frequency, percentage, and mean wherever applicable. The ThDP level of <75.0 nmol/L was considered as deficiency as defined by the New York Academy of Sciences.[6] Analysis of variance was used to compare the differences between age groups and a *p*-value of <0.05 was considered significant.

Ethical clearance was not sought from the ethical board as all the data presented were secondary laboratory data obtained from an outbreak investigation. Confidentiality was strictly maintained and no patient identifying details were divulged. Administration clearance for the retrospective analysis of data was also sought from the RCDC.

Results

A total of four suspected PN outbreaks from private schools and monastic institutes were reported during the study period. All outbreaks were reported from the Eastern region of the country (Figure 1). Overall, there were 107 cases involved. Samples from the three outbreaks were collected except the one from the Trongsa District (Table 1). The common clinical signs and symptoms reported among the suspected PN patients included pain and swelling of lower extremities, weakness of lower limbs, foot drop, paresthesia, and numbness.

Table 1. Number, signs and symptoms of cases in the suspected peripheral neuropathy outbreaks reported in four districts of Bhutan during 2020 to 2021 (n=107)

District	Date of event	Initial number of suspected cases	Signs and symptoms
Pema Gatshsel	5 Nov 2020	8	Suspected peripheral neuropathy
Trongsa	25 Jan 2021	51	Pain and swelling of lower extremities, weakness of lower limbs, foot drop
Tashigang	20 Jan 2021	39	Paresthesia, numbness, swelling of lower limbs
Tashiyangtse	2 Dec 2021	9	Suspected peripheral neuropathy

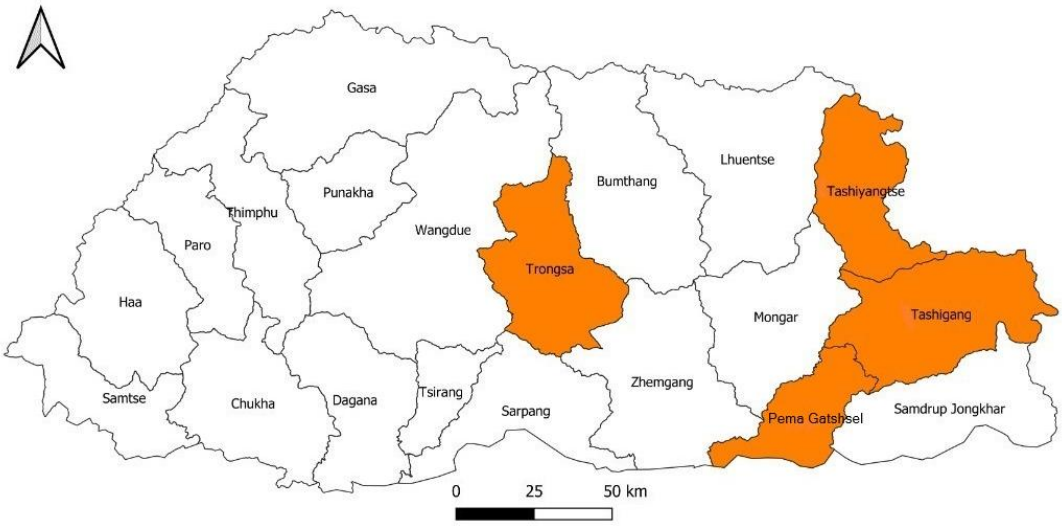

Figure 1. Four districts (highlighted) in Bhutan where suspected periphery neuropathy outbreaks were reported during 2020 to 2021

Among 56 cases in three suspected outbreaks, 34 blood samples were collected for laboratory tests. From the laboratory analysis of blood samples, thiamine deficiency was suspected to be the main cause of the outbreak. Of the 34 samples tested, 27 (79%) had ThDP levels <75.0 nmol/L and 7 (21%) had levels ≥75.0 nmol/L (Table 2). The mean ThDP level was 56.5 nmol/L and the mean age of those who had thiamine deficiency was 21 years (range 13–39).

Table 2. Characteristics and the whole blood ThDP levels of cases in suspected periphery neuropathy outbreak in three districts of Bhutan during 2020 to 2021 (n=34)

Outbreak district (year)	Mean age (years)	Gender n (%)		ThDP level n (%)	
		Male	Female	<75.0 nmol/L (Deficient)	>75.0 nmol/L (Adequate)
Pema Gatshsel (2020)	20	9 (45.0%)	11 (55.0%)	16 (80.0%)	4 (20.0%)
Tashigang (2021)	22	6 (100%)		4 (66.7%)	2 (33.3%)
Tashiyangtse (2021)	23	8 (100%)		7 (87.5%)	1 (12.5%)

Seventeen (50%) samples belonged to patients aged 10–20 years. Thiamine deficiency was found in 94.1%, 93.9% and 50% of those aged 10–20 years, 21–30 years and ≥30 years, respectively. The mean ThDP level was not significantly different among those in different age groups with *p*-value equal 0.79 (Table 3).

Table 3. The whole blood ThDP level of cases in suspected periphery neuropathy outbreak in three districts of Bhutan during 2020 to 2021, categorized by age group (n=34)

Age group (years)	Frequency n (%)	ThDP level (nmol/L) Mean (SD)	Thiamine deficiency, n (%)	*P*-value
10–20	17 (50.0%)	50.2 (24.6)	16 (94.1%)	0.79
21–30	15 (44.1%)	47.9 (23.6)	14 (93.3%)	
≥30	2 (5.9%)	174.7 (140.3)	1 (50.0%)	

Note: SD: Standard deviation

Discussion

Bhutan is experiencing a micronutrient deficiency problem. The National Nutrition Survey reported an anemia prevalence of 43.8% in children aged 6–23 months, 36.1% among females aged 10–49 years, 34.9% among women of reproductive age (15–49 years), 31.3% among adolescent girls, and 27.3% among pregnant women. Additionally, in 8% of the households surveyed, the residents had poor to borderline food consumption.[16] Realizing thiamine deficiency as a major problem among school-going children, the Nutrition Program, Department of Public Health recommended implementing a food fortification program in government feeding schools. The Ministry of Education shortly introduced fortified rice in 2017 in collaboration with the Ministry of Agriculture and Forests, the World Food Program, and the Ministry of Health. Fortified rice contains Vitamin A, B1 (Thiamine), B3 (Niacin), B6 (Pyridoxine), B9 (folic acid), B12 (cobalamin), iron and zinc.[17,18]

Globally, food fortification is recognized as the most effective intervention to combat micronutrient deficiencies.[19,20] Since the implementation of food fortification, no PN outbreaks have been reported from government feeding schools in Bhutan. However, the current PN outbreaks were reported from institutes and centers where fortified rice was not included in the daily meals. When staple crops such as polished rice or cassava are the main food items eaten by the population, thiamine deficiency is inevitable.[21] Dzed et al., (2015) reported that thiamine deficiency could be a huge problem in Bhutan as the intake of thiamine from dietary sources was very low.[11] The current PN outbreaks can be compared to the earlier sporadic PN outbreaks in the schools occurring before the implementation of food fortification where studies have attributed this to thiamine deficiency. An analysis of meals provided in feeding schools in Bhutan (2020) found that the meals served across the country were homogeneous with limited diversity, had a deficit in protein and most micronutrients, and non-vegetarian meals were served only 10 times (6.2%) out of 163 observations.[22] After the thiamine supplements were provided, the thiamine deficiency outbreak was resolved. Therefore, we conclude that the present outbreaks across three different districts could associate with thiamine insufficiency in regular diets.

The current outbreak was dominated by males (68%) and this could be because two of the three events occurred in institutes with high proportion of male, unlike in a previous study which found that all PN cases were female.[10] We also found that there was no significant difference in average ThDP level among the different age groups. Despite all the current outbreaks being reported from the Eastern region of the country, the limited sample size prevents generalizing thiamine outbreaks to this particular geographical location. However, the need for a national micronutrient survey is deemed necessary to create a baseline and for developing strategic programmatic interventions.

Limitations of the study

The main limitation of this study is that the history of individual cases, their symptoms and their potential risk factors were not available. Additionally, the limited number of samples tested prevented us from determining associated factors of developing thiamine deficiency.

Public Health Recommendations

Modifiable interventions such as dietary diversification, food fortification, including food processing and behavior change related to food procurement, and consumption practices and public awareness can help prevent micronutrient deficiencies.

Conclusion

This investigation found that of 34 samples tested for thiamine, 79% had ThDP levels <75.0 nmol/. Given the fact that micronutrient deficiency was established as the cause of the current PN outbreaks, we recommend that the supply of fortified rice across all the institutes (both government and private) in the country be initiated. Holistic approaches should be implemented to reduce the burden of micronutrient deficiencies in the country.

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Suggested Citation

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References

1. Smith TJ, Johnson CR, Koshy R, Hess SY, Qureshi UA, Mynak ML, et al. Thiamine deficiency disorders: a clinical perspective. Ann N Y Acad Sci. 2021 Aug;1498(1):9–28. doi:10.1111/nyas.14536.

2. Kliegman RM, Behrman RE, Jenson HB, Stanton BMD. Nelson textbook of pediatrics. 18th ed. Philadelphia (PA): Elsevier Health Sciences; 2007. Chapter 46.1, Thiamine (vitamin B1); p. 246–7.

3. Pawar RD, Balaji L, Grossestreuer AV, Thompson G, Holmberg MJ, Issa MS, et al. Thiamine supplementation in patients with alcohol use disorder presenting with acute critical illness: a nationwide retrospective observational study. Ann Intern Med. 2022 Feb;175(2):191–7. doi:10.7326/M21-2103.

4. Smith TJ, Hess SY. Infantile thiamine deficiency in South and Southeast Asia: an age-old problem needing new solutions. Nutr Bull. 2021 Mar;46(1):12–25. doi:10.1111/nbu.12481.

5. Bemeur C, Butterworth RF. Thiamin. In: Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR, editors, Modern nutrition in health and disease, 11th ed. Baltimore (MD): Lippincott Williams & Wilkins; 2014. p.317–24.

6. Whitfield KC, Bourassa MW, Adamolekun B, Bergeron G, Bettendorff L, Brown KH, et al. Thiamine deficiency disorders: diagnosis, prevalence, and a roadmap for global control programs. Ann N Y Acad Sci. 2018 Oct;1430(1):3–43. doi:10.1111/nyas.13919.

7. Sauberlich H. Biochemical alterations in thiamine deficiency—their interpretation. The Am J Clin Nutr. 1967 Jun;20(6):528–42. doi:10.1093/ajcn/20.6.528.

8. Lu J, Frank EL. Rapid HPLC measurement of thiamine and its phosphate esters in whole blood. Clin Chem. 2008 May;54(5):901–6. doi:10.1373/clinchem.2007.099077.

9. Wieringa FT, Dijkhuizen MA, Berger J. Micronutrient deficiencies and their public health implications for South-East Asia. Curr Opin Clin Nutr Metab Care. 2019 Nov;22(6): 479–82. doi:10.1097/MCO.0000000000000603.

10. ten T, Dzed L, Thinley S, Tshomo D, Dechen K, mo Z, et al. Investigation of suspected peripheral neuropathy outbreak in Dechentsemo Central School, Thinleygang, Punakha. Public Health of Indonesia. 2016 Sep;2(3):118–24. doi:10.36685/phi.v2i3.76.

11. Dzed L, Dorji T, Pelzom D, Dhakal GP, Yangchen P, Wangmo K. Status of thiamin deficiency in boarding school children from seven districts in Bhutan with previous history of peripheral neuropathy outbreaks: a cohort study. Bhutan Health Journal. 2015;1(1):49–56. doi:10.47811/bhj.08.

12. Pradhan D, Bhandari P, Gyeltshen D. 587 Infantile beriberi as a cause of acute infantile encephalopathy in a referral hospital in Southern Bhutan. Arch Dis Child. 2021 Nov;106:A49. doi:10.1136/archdischild-2021-rcpch.84.

13. Chhetri V, Pokhrel HP, Dorji T. A review on foodborne disease outbreaks in Bhutan. WHO South East Asia J Public Health. 2021 Jul–Dec;10(2):101–4. doi:10.4103/WHO-SEAJPH.WHO-SEAJPH_117_21.

14. Chhetri V, Dorji T, Monger A. Foodborne disease outbreaks linked to consumption of bakery products in Bhutan. Science Technology and Engineering Journal (STEJ). 2022;8(1):30–8.

15. Korner RW, Vierzig A, Roth B, Muller C. Determination of thiamin diphosphate in whole blood samples by high-performance liquid chromatography—a method suitable for pediatric diagnostics. J Chromatogr B Analyt Technol Biomed Life Sci. 2009 Jul 1;877(20–21):1882–6. doi:10.1016/j.jchromb.2009.05.013.

16. 2015 national nutrition survey (NNS). Thimphu (BT): Nutrition Program, Department of Public Health, Ministry of Health; 2015. 139 p.

17. Andrade JE, Ali ANMA, Chowdhury R, Crost B, Hoffmann V, Mustafa S, et al. Rice fortification in Bangladesh: technical feasibility and regulatory requirement for introducing rice fortification in public modern storage/distribution of fortified rice through PFDS channels. Washington: International Food Policy Research Institute (IFPRI); 2021 Aug. 116 p. doi:10.2499/p15738coll2.134540. IFPRP Working Paper 10.

18. Tamang PS, Dhakal GP, Bajgai GP, Chhetri V, Dzed L, Pokhrel HP. Investigation of oral lesion outbreak among two boarding school students in Thimphu. Asian Journal of Dietetics. 2021;3(1):19–22.

19. Keats EC, Neufeld LM, Garrett GS, Mbuya MNN, Bhutta ZA. Improved micronutrient status and health outcomes in low- and middle-income countries following large-scale fortification: evidence from a systematic review and meta-analysis. Am J Clin Nutr. 2019 Jun 1;109(6):1696–708. doi:10.1093/ajcn/nqz023.

20. Mkambula P, Mbuya MNN, Rowe LA, Sablah M, Friesen VM, Chadha M, et al. The unfinished agenda for food fortification in low- and middle-income countries: quantifying progress, gaps and potential opportunities. Nutrients. 2020 Jan 29;12(2):354. doi: 10.3390/nu12020354.

21. Gomes F, Bergeron G, Bourassa MW, Fischer PR. Thiamine deficiency unrelated to alcohol consumption in high-income countries: a literature review. Ann N Y Acad Sci. 2021 Aug;1498(1):46–56. doi: 10.1111/nyas.14569.

22. Sherpa PL, Pokhrel HP, Dzed L, Deki K. Nutritive analysis of school meals: an investigation of a one-day meal provided in feeding schools of bhutan. Asian Journal of Dietetics. 2020;2(2):59–64.

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Investigation of a COVID-19 Cluster Suspected In-flight Transmission, December 2020

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Abstract

On 1 Dec 2020, the Thai Department of Disease Control was notified of five COVID-19 infections among passengers on a flight from Switzerland to Thailand. The objectives of this investigation were to confirm the outbreak, describe epidemiological characteristics, and identify the source of infection. We performed a descriptive study and contact tracing among the flight's passengers. We interviewed the cases and reviewed their medical records, as well as an environmental survey of the state quarantine facility. Whole genome sequencing to determine the percentage alignment identity for RT-PCR-positive cases was conducted. Thirteen infected passengers out of 107 people on the flight (12.1%) were identified. The suspected index case was a symptomatic passenger, non-mask-wearing passenger. Five of the 13 confirmed cases shared a similar genomic pattern (98–100% alignment identity), and four cases sat within one row either in front of or behind the suspected index case. The genomes of the cases were more similar to each other than those uploaded to the GISAID database from Switzerland. The symptomatic COVID-19 passenger without mask wearing was suspected to be the source. Mask wearing should be mandated on flight to prevent spreading of respiratory infectious diseases.

Keywords: COVID-19, in-flight transmission, on plane transmission, airplane transmission, coronavirus, respiratory virus

Introduction

Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Human-to-human transmission occurs through nasal secretion, phlegm and saliva via airborne droplets in closed space and via fomites. COVID-19 can be prevented by mask-wearing, frequent hand-washing, and physical distancing.[1] Previous studies suggest that the virus can be transmitted during air travel.[2,3] Airlines' measures to control in-flight transmission of COVID-19 include mask-wearing, limited cabin service, in-flight cleaning of sanitary facilities, and ventilation using high-efficiency particulate absorbing filters.[4] Since 6 Jul 2020, wearing masks have been compulsory on public transport across Switzerland, including trains, buses and resort elevator systems. Switzerland's Federal Council announced that wearing masks during flights in and out of Switzerland became compulsory from 15 Aug 2020.[5] Measures to control COVID-19 in Thailand related to international flights in 2020 were as follows: travelers who had fever or respiratory symptoms on arrival would be tested for SARS-CoV-2 at the airport while other travelers would be placed in quarantine facilities for observation of symptoms for at least 14 days from the date of arrival with respiratory samples collected twice for SARS-CoV-2 testing.[6–8]

On 1 Dec 2020, staffs from the Department of Disease Control of Thailand were notified by the Office of Disease Prevention and Control Region 6 Chonburi

that there were five patients infected with SARS-CoV-2 who had traveled from Switzerland on flight LX180 arriving at Suvarnabhumi Airport on 25 Nov 2020. The objectives of this investigation were to confirm the outbreak, describe epidemiological characteristics of the cases and to identify the source of infection and mode of transmission.

Methods

We applied a descriptive study design. Data collection techniques consisted of interviews with the cases and state quarantine (SQ) center staffs, review of medical records and flight history, and an environmental survey of the SQ center. The cases were interviewed using a semi-structured questionnaire with a focus on their in-flight behaviors and their travel history in Thailand. The flight history of the cases and related passengers, including the travel history on the bus to the quarantine center, was reviewed.

We performed contact tracing of passengers on the flight and in SQ using 'Guideline for Surveillance and Case Investigation for Coronavirus Disease 2019 (COVID-19)' version 15 (on May 2020) by the Department of Disease Control, Thai Ministry of Public Health.[9] We defined a confirmed case as a passenger or cabin crew in this fight that tested positive for SAR-CoV-2 by multiplex reverse transcription-polymerase chain reaction (RT-PCR) from at least one certified laboratory in Thailand during 21 Nov to 9 Dec 2020. A close contact was defined as any person interacting with a confirmed case within a one-meter distance for at least five minutes, or being coughed or sneezed on, or seated within two rows with a confirmed case. A close contact was further categorized as high risk if they took their face mask off during the flight or low risk if they wore their face mask continuously during the flight, except while eating and drinking.

We performed a laboratory study and a brief environmental survey. For the laboratory study, the cases undertook a nasopharyngeal swab to test for genetic materials of SARS-CoV-2 by RT-PCR from a certified laboratory designated by the Department of Medical Sciences. A positive result was defined as a cycle threshold value of less than 40. All positive samples were sent to the National Institute of Health of Thailand or Thai Red Cross Emerging Infectious Diseases Health Science Centre, Chulalongkorn Hospital for whole genome sequencing (WGS) with a genome size of 29,903 base pairs. The nucleotide sequence data of the SARS-CoV-2 viral genome of cases were extracted by the Illumina® MiSeq™ system. We created a DNA substitution and analyzed the molecular evolutionary relationship (phylogenetic tree) using the IQ-TREE program under a maximum likelihood algorithm with bootstrapping using 1,000 iterations and percent alignment identity calculation using Geneious Prime version 2021.2.2. DNA sequence alignments were compared between confirmed cases on the flight using the first case detected at the airport as the baseline. We also compared the confirmed cases with a reference sequence obtained from Swiss SARS-CoV-2 samples, which were uploaded to the Global Initiative on Sharing Avian Influenza Data (GISAID) database in November 2020.[10]

For the environmental study, we interviewed physicians at the SQ, the manager at the hotel, the SQ commander, and infectious disease nurses about their infection control processes, including transportation hygiene and cleaning methods, using a semi-structured questionnaire. An environmental survey at the SQ was done by non-participant observation using 'Guidance for Integrated Management of State Quarantine Facilities' by the Thai Ministry of Public Health.[8]

For the descriptive analysis, categorical data were presented as frequency and percentage, while continuous data were presented as median and interquartile range.

This investigation was performed under a public health emergency. The names of participants were not collected. Invasive techniques were not used and all participants willingly and verbally gave their informed consent to participate.

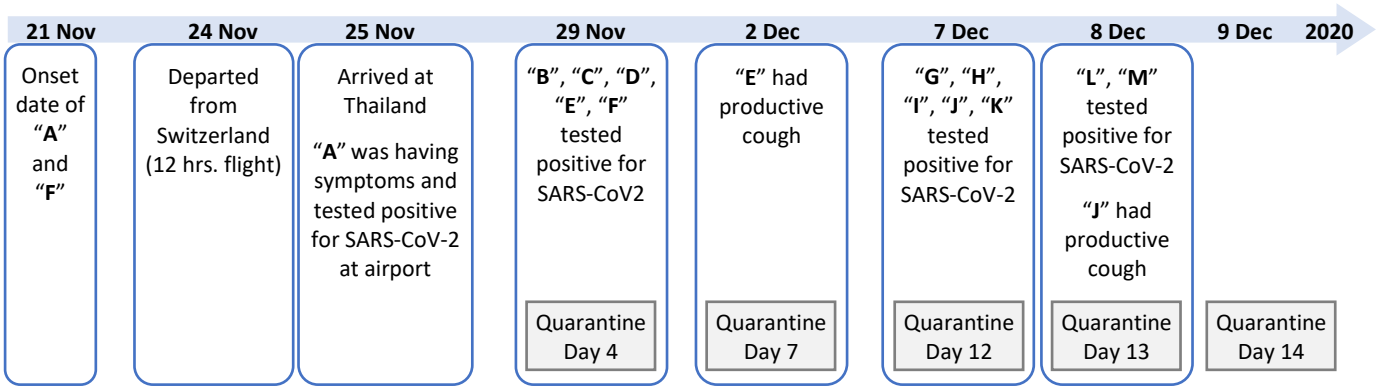
Results

Descriptive Characteristics of the Cases

Swiss airlines flight LX180 departed from Zurich Airport on 24 Nov 2020 and arrived in Bangkok on 25 November. The flight time was approximately 12 hours. One meal was served on the flight, which contained a total of 107 people including two pilots, seven flight attendants and 98 passengers, of which 11 were seated in first/business class and 87 in economy class. All passengers had negative results of COVID-19 testing via RT-PCR within 72 hours before the flight.

Only 13 passengers from the economy class were tested positive and diagnosed with COVID-19 during 21 Nov to 9 Dec 2020. The crude attack rate for the whole flight was 12.1% while the attack rate among all passengers was 13.3% and the attack rate among passengers seated in economy class was 14.9%. twelve of the 13 cases were female. The median (interquartile range) age among cases was 56 (48–61) years and most were housewives. All were admitted to hospital

in a COVID-19 ward and there was no intensive care unit admission. None required oxygen support. Nine of the 13 cases were asymptomatic (69.2%). The four symptomatic cases all had productive cough (30.8%). One case developed other symptoms included diarrhea, runny nose, anosmia, and fever (7.7%). At the time of our investigation, COVID-19 vaccines were not available. Two of the four symptomatic cases developed productive cough on 21 Nov 2020, three days before the flight departed. One of them was the first detected case (case "A") after she was tested positive for SARS-COV-2 at Suvarnabhumi Airport and sent to hospital. The remaining passengers were taken to a SQ center for 14 days and tested for SARS-CoV-2. Five passengers ("B"–"F") tested positive for SARS-CoV-2 on 29 November (day 4), five ("G"–"K") tested positive on 7 December (day 12), and two ("L" and "M") on 8 December (day 13). A timeline of symptoms development among these 13 cases is shown in Figure 1.



Note: SARS-CoV-2 testing of "L" and "M" on day 12 was inconclusive; their specimens were recollected on day 13.

Figure 1. Timeline of COVID-19 development among 13 passengers (A–M) on board flight LX180 from Switzerland

The flight's economy class seating plan is presented in Figure 2. Thirty-five passengers were seated within two rows of case "A". Of which, 14 had symptoms before travelling and 21 did not. Among these 14 pre-flight symptomatic and 21 asymptomatic passengers, the attack rates were 36% (5/14) and 5% (1/21), respectively.

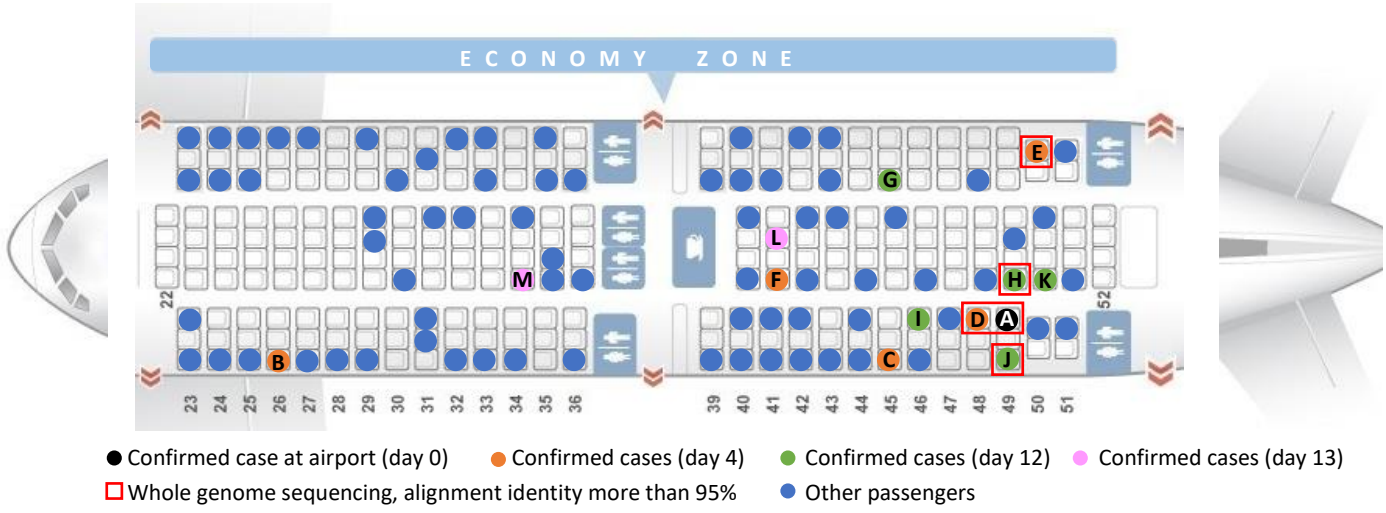


Figure 2. Seating plan of economy class on board flight LX180 from Switzerland

Exposure History

The 13 confirmed cases were from 13 different cities in Switzerland and had never known or met each other before boarding the plane. None of them had a contact history with any confirmed COVID-19 case in Switzerland. All cases visited supermarkets or department stores once or twice within two weeks before boarding the flight.

Case "A" had productive cough and sneezing during the flight. She often took off her face mask during mealtimes, after coughing and sneezing, and while she was talking to other passengers. Other passengers said that she talked to other passengers on the airplane frequently. Other passengers wore their face masks all the time, except during mealtimes. Case "F", the other case who had symptoms before travelling, did not talk to any passengers or go to the toilet. Passengers seated

in row 46 and behind used toilets at the back of the airplane, while the others used the ones in the middle.

The passengers travelled to the SQ center by bus, adhered to physical distancing restrictions, and always wore their face mask. At the quarantine center, none of the cases had any physical contact with each other. All stayed in their room, except during the registration process and specimen collection when they met SQ staffs, who were wearing full personal protective equipment (hair net, face-shield, N95 mask, gown or coverall, gloves, shoes or leg covers). Everyone had to self-monitor their symptoms and report if they developed any symptoms to SQ staff by phone. Communal places were cleaned every one to two hours. The SQ staff supervisor worked to prevent transmission within the SQ. None of SQ staff developed any symptoms within 14 days after contacting with those cases.

Laboratory Result

Ten of 13 were tested by WGS. Nine of them had results of CT values less than 30. Laboratory results showed that all 13 cases had the GH clade. The first case, "A", was most like case "D", who was seated directly behind and talked to case "A" on the plane, with 100% identity. The likeness of case "A" with cases "E"," H", and "J" was 98%. The sequences of cases "D", "E", "H", and "J" were closer to case "A" than other Swiss SARS-CoV-2 sequences that were uploaded to the GISAID database. The phylogenetic tree of cases "A", "D", "E", "H", and "J" are shown in Figure 3, and the laboratory results are shown in Table 1.

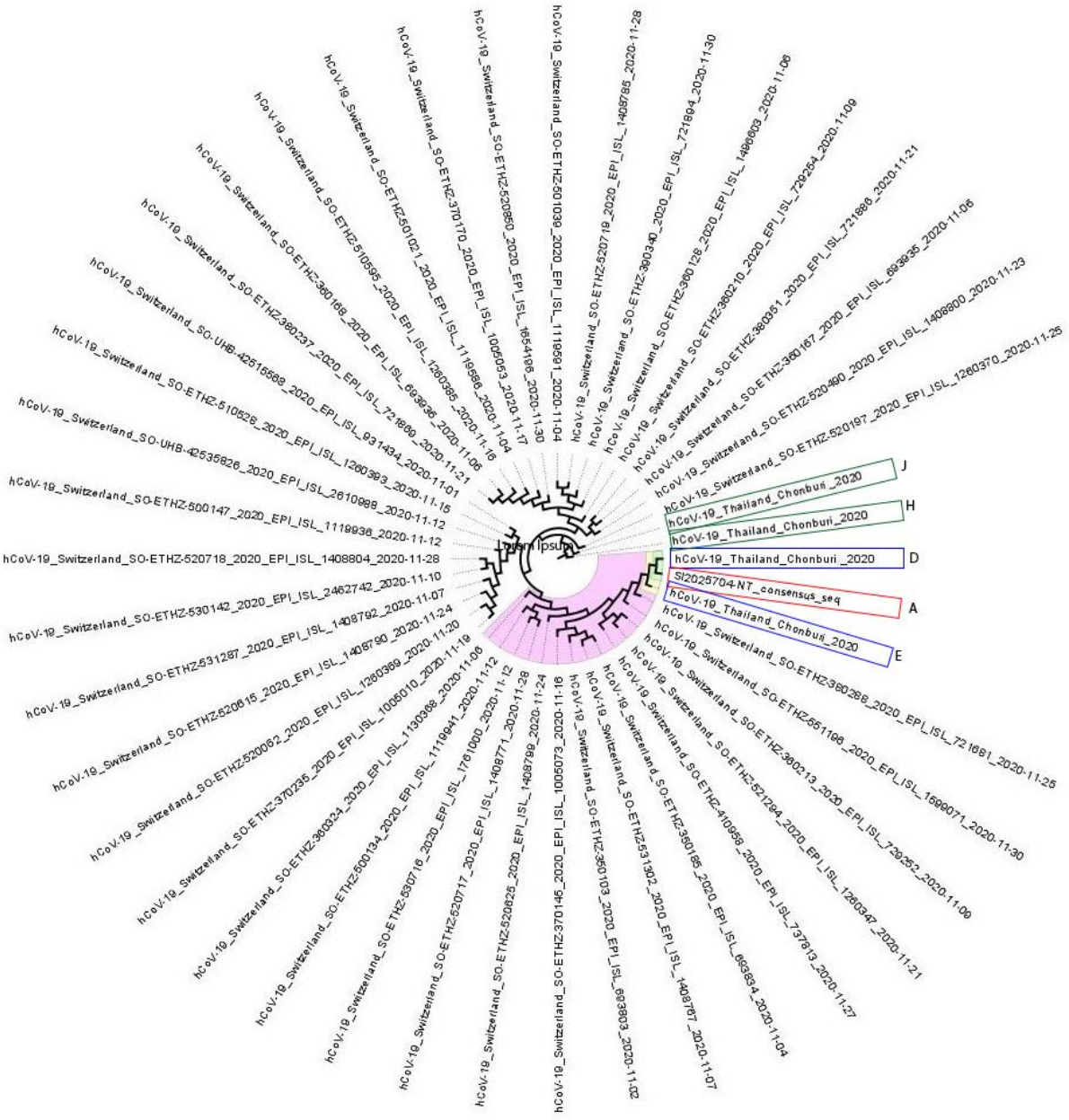


Figure 3. Phylogenetic tree of five positive COVID-19 cases on board flight LX180 from Switzerland

Table 1. Laboratory results of 13 COVID-19 cases on board flight LX180 from Switzerland

Case	Laboratory positive date in 2020	Day after arrival	N gene	ORIF1ab gene	Seat	Onset of symptoms	Alignment identity	Departed city
A	25 November	0	21.61	E gene=18.23	49C	21 November	Baseline	Solothurn
B	29 November	4	17.33	17.89	26A	-	85%	Rheinfelden
C	29 November	4	27.7	27.2	45A	-	85%	Zurich
D	29 November	4	11.35	11.84	48C	-	100%	Martigny
E	29 November	4	18.33	17.95	50K	29 November	98%	Bern
F	29 November	4	30.38	30.17	41D	21 November	85%	Lausanne
G	7 December	12	25.46	22.56	45H	-	85%	Montreux
H	7 December	12	24.76	22.47	49D	-	98%	Neftenbach
I	7 December	12	24.47	22.27	46C	-	92%	Wurenlos
J	7 December	12	24.62	22.36	49A	8 December	98%	Grenchen
K	7 December	12	32.60	30.81	50D	-	85%	Bern
L	8 December	13	38.68	36.47	41F	-	-	Schwyz
M	8 December	13	38.69	34.86	34D	-	-	Zurich

Discussion

This COVID-19 outbreak on a 12-hour flight consisted of 13 confirmed cases seated in economy class with limited in-flight service. Five of these 13 cases shared both epidemiological (seated in the same row or 1 row in front or behind and talking to a symptomatic case) and laboratory linkages to the index case (case "A"). All of their samples had the GH clade and nine were asymptomatic. This in-flight cluster was slightly different from that reported by Hamed et al on the global dynamics of SARS-CoV-2 clades and their relation to COVID-19 epidemiology where 49% of cases found to be infected with GH clade were mild or asymptomatic.[11] On the other hand, all cases in this outbreak were mild or asymptomatic, probably because the severe cases could not travel abroad.

Two of the 13 cases had symptoms before travelling. Thus, these cases were likely to be infected before they boarded the plane. The attack rate among close contacts (passengers seated within two rows in front and behind) of the index case was higher than the attack rate among close contacts of another symptomatic case (case "F") seated eight rows back. Case "A" was therefore the most likely person to have spread the disease to the other passengers. This passenger had symptoms such as productive cough and sneezing during the flight and talked to other passengers without wearing a mask. A study in China suggested that symptomatic cases were more likely to spread COVID-19 than asymptomatic cases.[12]

A meta-analysis suggested that face mask wearing could significantly reduce the risk of SARS-CoV-2 infection (odds ratio 0.44, 95% CI 0.21–0.93, I^2 52.0%).[13] An experimental study of respiratory virus shedding in exhaled breath and efficacy of wearing face masks reported that coronavirus in respiratory droplets and aerosols in samples collected from ten infectious participants who were not wearing face masks, while they did not detect any of the virus in respiratory droplets or aerosols collected from the participants when they were wearing face masks.[14] These studies suggest that wearing a face mask is a key for preventing the spread of contagious diseases.[15] Moreover, they support the evidence that the first case who often taking mask off could be the cause of the spreading in this flight.

A study investigating the transmission of SARS-CoV-2 during a long flight in 2020 found that among the 16 persons in whom SARS-CoV-2 infection was detected, 12 were passengers seated in business class together with the only symptomatic person and the attack rate was 62%. Seating proximity was strongly associated with increased infection risk (risk ratio 7.3, 95% CI 1.2–46.2).[3]

In this study, we assumed that transmission of SARS-CoV-2 during a flight could occur within one row in front and behind of the index case. In-flight transmission occurs due to laminar airflow in which air enters the cabin from overhead inlets and flows downward toward the floor level outlets at the same and nearby rows. A study by Pombal and Hosegood showed that, in a modern airplane used in commercial flight nowadays, air flows mostly within the rows—the amount of air flowing between the rows is low. Thus, the chance of transmission between rows on a plane is minimal.[3] Another study investigating in-flight transmission of SARS-CoV-2 in Hong Kong suggested that cases from different countries belonged to the

same in-flight transmission chain with 100% identity across the near full-length viral genomes (sequence length ≥29,760 nucleotides).[2] Another study found that the risk of infection in aircraft lavatories is low.[16]

On this flight, cases "D", "E", "H", and "J" were closer to case "A" than other Swiss SARS-CoV-2 sequences uploaded to the GISAID database. They all had alignment identity 98% and 100% matched. Therefore, they were likely to be infected by case "A". For other cases, we could not determine the source of their infection. They could have been infected during the flight or before boarding the plane because all of their samples belonged to the GH clade and they all came from Switzerland.

According to the interviews, the SQ staff followed the standards of the Guidance for Integrated Management of State Quarantine Facilities of the Thai Ministry of Public Health. There was no high-risk contact in the facility since there were no confirmed cases that met other passengers.[7] The risk of infection on the way to and at the SQ was low and less likely to be a source of infection.

Limitations

There are a few limitations in this study that should be mentioned. First, there is a lack of agreement concerning the cut-off value for alignment identity of WGS for SARS-CoV-2 for determining the source of infection. We assumed that as the percentage of alignment increases, the likelihood that the infection was from the same source increases. Second, we could not conduct a direct environmental survey on the plane nor interview airline staff. However, we did interview some of the passengers, although memory bias might be an issue as some activities, especially mask wearing and hand washing, happened long before the diagnosis was confirmed. We attempted to minimize this bias by triangulating the interview data with various other sources which were other passengers and state quarantine staff.

Public Health Recommendations

The governments of all countries should communicate with their citizens abroad and emphasize the importance of risk-minimizing behaviors such as mask wearing and physical distancing at all times, particularly during the flight and upon arrival in the destination country. Mask wearing on the flight should be mandatory to reduce the risk of spreading any respiratory infectious diseases.[17] In-flight high-risk contact tracing for any respiratory infectious disease should be performed on passengers seated within one row in front and one row behind the index case, including passengers seated across the aisle. Symptomatic cases should be screened on arrival at the airport to isolate suspected cases. Contact tracing of high-risk contacts should also be conducted. Even though COVID-19 may not be a serious public health threat anymore due to the vaccination, these control measure could be adapted to other emerging respiratory infectious diseases. SQ prevented transmission of the new emerging respiratory infectious diseases from abroad to community. SQ centers during the early of pandemic without vaccination or specific and effective treatment such as antiviral drugs would prevent the emerging of large clusters of cases.[18]

Conclusion

We investigated a cluster of COVID-19 cases on a 12-hour flight from Switzerland to Thailand in December 2020. There were 13 passengers infected, giving a crude attack rate of 12%. All of the cases were from different cities in Switzerland. Five of the cases shared a very similar genomic pattern (98–100% WGS alignment identity). A symptomatic COVID-19 passenger not wearing a mask was suspected as the source, supported by epidemiological and laboratory findings. The Thai government should communicate with its citizens to emphasize the importance of mask wearing and practicing social distancing when living abroad. Mask wearing on all flights should be mandatory during the early of pandemic where effective vaccination or specific and effective treatments are not available.

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References

1. World Health Organization. WHO Coronavirus Disease (COVID-19) Dashboard [Internet]. Geneva: World Health Organization; 2020 [cited 2020 Sep 15]. <https://covid19.who.int>

2. Choi EM, Chu DKW, Cheng PKC, Tsang DNC, Peiris M, Bausch DG, et al. In-flight transmission of SARS-CoV-2. Emerg Infect Dis [Internet]. 2020 Nov [cited 2020 Oct 5]; 26(11):2713–6. doi:10.3201/eid2611.203254.

3. Khanh NC, Thai PQ, Quach HL, Thi NAH, Dinh PC, Duong TN, et al. Transmission of severe acute respiratory syndrome coronavirus 2 during long-haul flight. Emerg Infect Dis. 2020 Nov; 26(11):2617–24. doi:10.3201/eid2611.203299.

4. Pombal R, Hosegood I, Powell D. Risk of COVID-19 during air travel. JAMA. 2020 Oct 1;324(17):1798. doi:10.1001/jama.2020.19108.

5. Swiss Federal Office of Public Health, Communications. Coronavirus: large-scale events to be permitted from October under strict conditions and with a permit [Internet]. Bern (Switzerland): Federal Council; 2020 Aug 12 [cited 2020 Sep 15]. <https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-80054.html>

6. Department of Disease Control Thailand. Measures to control COVID-19 version 5 updated on 2 April 2020. Nonthaburi: Department of Disease Control Thailand; 2020 Apr 2. 2 p.

7. Regulation Issued under Section 9 of the Emergency Decree on Public Administration in Emergency Situation B.E. 2548 (2005) (No.12). Royal Thai Government Gazette Volume 137, Special part 153 Ngor (Dated 2020 Jun 30):35.

8. Ministry of Public Health Thailand. Guidance for integrated management of state quarantine facilities. Nonthaburi: Ministry of Public Health Thailand: 2020 Jun 20. 36 p.

9. Ministry of Public Health Thailand. Guideline for Surveillance and Case Investigation for Coronavirus Disease 2019 (COVID-19). Nonthaburi: Ministry of Public Health (TH); 2020 May 15.

10. Elbe S, Buckland-Merrett G. Data, disease and diplomacy: GISAID's innovative contribution to global health. Glob Chall. 2017;1(1):33-46. doi:10.1002/gch2.1018.

11. Hamed SM, Elkhatib WF, Khairalla AS, Noreddin AM. Global dynamics of SARS-CoV-2 clades and their relation to COVID-19 epidemiology. Sci Rep. 2021 Apr 19;11(1):8435. doi:10.1038/s41598-021-87713-x

12. Chen Y, Wang AH, Yi B, Ding KQ, Wang HB, Wang JM, et al. [Epidemiological characteristics of infection in COVID-19 close contacts in Ningbo city]. Zhonghua Liu Xing Bing Xue Za Zhi. 2020 May 10;41(5):667–71. Chinese. doi:10.3760/cma.j.cn112338-20200304-00251.

13. Li Y, Liang M, Gao L, Ayaz Ahmed M, Uy JP, Cheng C, Zhou Q, Sun C. Face masks to prevent transmission of COVID-19: A systematic review and meta-analysis. Am J Infect Control. 2021 Jul;49(7):900–6. doi:10.1016/j.ajic.2020.12.007.

14. Leung NHL, Chu DKW, Shiu EYC, Chan KH, McDevitt JJ, Hau BJP, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nat Med. 2020 May;26(5):676–80. doi:10.1038/s41591-020-0843-2.

15. Howard J, Huang A, Li Z, Tufekci Z, Zdimal V, van der Westhuizen HM, et al. An evidence review of face masks against COVID-19. Proc Natl Acad Sci U S A. 2021 Jan 26;118(4): e2014564118. doi:10.1073/pnas.2014564118.

16. Vardoulakis S, Espinoza Oyarce DA, Donner E. Transmission of COVID-19 and other infectious diseases in public washrooms: A systematic review. Sci Total Environ. 2022 Jan 10;803: 149932. doi:10.1016/j.scitotenv.2021.149932.

17. John Milne R, Delcea C, Cotfas LA. Airplane Boarding Methods that Reduce Risk from COVID-19. Saf Sci. 2020 Oct 26:105061. doi:10.1016/j.ssci.2020.105061.

18. Jivaramonaikul T, Nittayasoot N, Suphanchaimat R. An investigation of a coronavirus disease (COVID-19) cluster from Saudi Arabia, in a state quarantine Chonburi, Thailand, 2020. OSIR. 2021 Dec;14(4):121–6.

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Preventive Behaviors and Seroprevalence of SARS-CoV-2 Antibodies from Natural Infection among Immigration Police Working at Don Mueang International Airport, Thailand, before the COVID-19 Vaccination Era

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Abstract

After the first wave of the COVID-19 pandemic in Thailand in 2020, there was no data related to preventive behaviors against COVID-19 infection and prevalence of previous infections among frontline immigration police, which could be used to implement health promotion and adapt preventive methods in the organization. All frontline immigration police officers working at Don Mueang International Airport, Bangkok, were invited to participate in this cross-sectional study in May 2020. The objectives were to describe their preventive behaviors and determine the prevalence of antibodies against SARS-CoV-2 using conventional neutralization assays and ELISA tests. There were 201 eligible participants. All were asked to fill in a questionnaire, which asked them to disclose their preventive behaviors against COVID-19 infection. All were tested for antibodies against SARS-CoV-2 from natural infection as vaccines were not available at that time. The most practiced preventive behaviors were wearing a mask at work and wearing a mask in daily life, while taking sick leave when suffering from respiratory symptoms was the least practiced behavior. No SARS-CoV-2 antibodies were present in any participant. Reasons for not taking sick leave, when necessary, should be investigated in further qualitative studies.

Keywords: COVID-19, SARS-CoV-2, antibody, preventive behavior, seroprevalence, immigration police

Introduction

Before the COVID-19 pandemic was declared by World Health Organization on 11 Mar 2020, Thailand was the most popular country for Chinese tourists.[1] During the period between the first reported COVID-19 case in China and the World Health Organization declaration, there were numerous direct flights between Thailand and China and the majority of COVID-19 cases were imported from China. After two outbreak events in Bangkok, March 2020, local transmission became the primary source of infection in Thailand.[2] However, infected international tourists were a major concern for further outbreaks. Don Mueang International Airport is one of the two international airports in Bangkok. The airport has many direct flights from many countries including China, and immigration officers have been the frontline workers facing a high risk of contracting COVID-19 and potentially spreading it to others. This study aimed to describe and compare preventive behaviors, and determine the seroprevalence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antibodies among frontline immigration police officers at Don Mueang

International Airport after the first wave of the COVID-19 epidemic in Thailand. Assessment of preventive behaviors among these essential workers was undertaken to identify potential gaps in occupational safety when interacting with travelers who could be infected with SARS-CoV-2. This information would provide crucial implications not only for safeguarding the immigration police but also for ensuring safe immigration control at the airport during the COVID-19 pandemic and beyond.

Materials and Methods

Study Population and Setting

All immigration police officers working within two meters of international travelers at Don Mueang International Airport from January to May 2020 were asked to participate in this study in May 2020. The participants were informed about the research objectives and related procedures. Written informed consent was obtained before enrolment. Participants were excluded if they reported immunocompromised conditions such as active cancer, HIV-AIDS, and the current use of steroids due to the low response for neutralization assay, and the possibility of false negative results.

Outcome Measurement

Preventive behaviors

All consenting immigration officers were asked to fill in a questionnaire, which consisted of two parts, namely demographic data and preventive behaviors. The preventive behaviors were divided into personal hygiene and work-related preventive behaviors. Personal hygiene consisted of seven questions, while work-related preventive behaviors consisted of three questions. Because the risk of working during the first period of the COVID-19 pandemic was considered to be the most possible mode of viral transmission, participants were categorized as having good work-related preventive behaviors if their answers to all three sub-questions were "always" and poor otherwise.

Seroprevalence of SARS-CoV-2 antibodies

Blood was drawn from all participants in a designated area at the Department of Disease Control Unit on the first floor of Terminal 1, Don Mueang International Airport in May 2020. Samples were stored and transported at a proper temperature of around four degrees Celsius to the Faculty of Medical Technology, Mahidol University. The serum was tested for SARS-CoV-2 antibodies by Conventional Neutralization Assay and WANTAI enzyme-linked immunosorbent assay (ELISA) (Beijing Wantai Biological Pharmacy Enterprise Co., Ltd.).

For the process and procedures of ELISA, laboratories followed every procedure from the brand and provided positive and negative control for the test. Based on previous studies, the sensitivity of WANTAI ELISA for SARS-CoV-2 ranged from 86–100%, depending on the time that patients were tested after their first debut, and the specificity was 96.9–99.2%.[3–5]

For the neutralization assay, which measured total immunoglobulin that can neutralize the virus, the antibodies will increase after the person is infected for around three to four weeks. In this study, we used a microneutralization test in Vero cell, which originated from a monkey's kidney, incubated into a cell monolayer one day before the test, and used SARS-CoV-2 at fifty-percent tissue culture infective dose. In the test, neutralizing antibody titers could be detected at a level as low as 1:10. The microneutralization assay was considered to be the most sensitive and specific test and can be used as a gold standard.[6]

We defined a case as SARS-CoV-2 infection from our positive laboratory results, in which SARS-CoV-2 infection was identified as positive once conventional Neutralization Assay (cNA) was positive regardless of the ELISA test result due to its high specificity.[7,8] If only ELISA was positive, an additional test of immunofluorescent assay would be applied due to ELISA's lower specificity and the possibility of cross-reactivity from other diseases, and the positive result was confirmed when both ELISA and immunofluorescent assay were positive.[9] Since there were no vaccines available at the time of this study, a positive antibody was interpreted as evidence of prior SARS-CoV-2 infection.

The study was approved by Mahidol University Central Institutional Review Board (protocol number MU-COVID2020.001/2503).

Statistical Analysis

Participants' characteristics were summarized using descriptive statistics. Independent samples t-test and the two-sample Wilcoxon rank-sum test were applied to compare the difference in means and distributions of continuous variables between participants who were deemed to have good and poor work-related preventive behaviors. The equality of variance between groups was assessed before applying the independent samples t-test. Exact probability was applied to compare proportions between groups.

All preventive behaviors were measured regarding the frequency of doing that behavior using a 4-point Likert scale ranging from rarely (<20%), sometimes (20–50%), often (51–95%), and always (>95%), and were described using the median and interquartile range.

Results

Demographic Characteristics

Of 201 eligible immigration police officers, all agreed to participate in the study and none were excluded. The majority of participants were female, younger than 35 years, and had no history of upper respiratory tract infection from January to May 2020. The median duration of employment was 9 months and the range was 2 months to 32 years. Most participants spent 8 hours and confronted approximately 200 international passengers per day from January to May 2020. RT-PCR testing for SARS-CoV-2 was performed on nearly 60% of all participants, with 22% experiencing some respiratory symptoms, and all results were negative (Table 1).

Table 1. Demographic characteristics of Thai immigration police officers working against COVID-19 at Don Mueang International Airport, disaggregated by level of the work-related preventive behaviors on preventing COVID-19

Demographic characteristics	Total	Good*	Poor
	n (%)†	n (%)‡	n (%)‡
Overall‡	201	30 (14.9)	171 (85.1)
Gender			
Male	51 (25.4)	4 (7.8)	47 (92.2)
Female	150 (74.6)	26 (17.3)	124 (82.7)
Age (years)			
Mean (SD)	33.4 (9.6)	34.3 (10.4)	33.2 (9.4)
Range	19–58	20–56	19–58
Age group (years)			
≤35	131 (65.2)	19 (14.5)	112 (85.5)
36–45	41 (20.4)	7 (17.1)	34 (82.9)
>45	29 (14.4)	4 (13.8)	25 (86.2)
Duration of work experience (months)			
Median (IQR)	9 (34)	9.0 (60)	9.0 (25)
Range	2–392	7–392	2–292
≤12	116 (57.7)	17 (14.7)	99 (85.3)
>12	85 (42.3)	13 (15.3)	72 (84.7)
Number of passengers contacted (per day)			
Median (IQR)	200 (400)	225 (400)	200 (400)
Range	5–12000	10–12000	5–12000
≤100	65 (32.3)	9 (13.8)	56 (86.2)
>100	136 (67.7)	21 (15.4)	115 (84.6)
Duration of contact with passengers (minutes)			
Median (IQR)	480 (300)	450 (240)	480 (360)
Range	2–1440	60–600	2–1440
≤60	39 (19.4)	3 (7.7)	36 (92.3)
>60	162 (80.6)	27 (16.7)	135 (83.3)
History of upper respiratory tract illness			
No	156 (77.6)	23 (14.7)	133 (85.3)
Yes	45 (22.4)	7 (15.6)	38 (84.4)
History of nasopharyngeal swab screening (RT-PCR)			
No	84 (41.8)	16 (19.0)	68 (81.0)
Yes	117 (58.2)	14 (12.0)	103 (88.0)

Note: SD: standard deviation, IQR: interquartile range. †Percentage by column, ‡Percentage by row

**Good work-related preventive behaviors; replied 'always' in all three work-related preventive behaviors shown in Table 2.*

Preventive Behaviors

The most common preventive behaviors were wearing masks in daily life and wearing masks at work. Not using share belonging, cleaning hands in daily life and during work, were always done consecutively after wearing masks. The least common behavior was taking sick leave after a respiratory tract ailment, followed by cleaning personal or shared belongings and use of cashless payment systems, consecutively (Table 2).

Generally, most participants practice all preventive behaviors in "personal hygiene care" at the level of "often" and "always", with the median score of the preventive behavior's frequency of at least three. However, taking sick leave when having respiratory symptoms had the lowest median score of two. Most (85.1%) participants had poor work-related preventive behaviors. There were no significant differences between participants' characteristics and their level of work-related preventive behaviors (Table 1).

Table 2. Frequency of preventive behaviors against contracting and being exposed to COVID-19 among Thai immigration police officers working at Don Mueang International Airport

Questions	Rarely (1)	Sometimes (2)	Often (3)	Always (4)	Median (IQR)
	n (%)	n (%)	n (%)	n (%)	
Overall					
Personal hygiene care					
1. How often did you clean your hands with alcohol gel or hand sanitizer after going to the restroom, before having food, or touching any share belonging? (cleaning hands in daily life)	0 (0)	4 (2.0)	73 (36.3)	124 (61.7)	4 (3–4)
2. How often did you pay for items via cashless system, such as credit card, or QR code? (use of cashless payment systems)	16 (8.0)	53 (26.4)	96 (47.8)	36 (17.8)	3 (2–3)
3. How often did you touch your face (including mouth, nose, eyes)?† (touching face)	3 (1.5)	35 (17.4)	82 (40.8)	81 (40.3)	3 (3–4)
4. How often did you use shared belongings, such as dish, spoon, or glass?† (not using share belonging)	2 (1.0)	18 (9.0)	44 (21.9)	137 (68.1)	4 (3–4)
5. How often did you clean your belonging/ sharing parts of your residence (such as cleaning door knob, mobile phone at least once daily)? (cleaning personal or shared belongings)	16 (8.0)	77 (38.3)	80 (39.8)	28 (13.9)	3 (2–3)
6. How often did you practice physical distancing (being at least 1 meter away from others)? (physical distancing)	1 (0.5)	23 (11.4)	123 (61.2)	54 (26.9)	3 (3–4)
7. How often did you wear a mask before going out? (wearing masks in daily life)	0 (0)	2 (1.0)	12 (6.0)	187 (93.0)	4 (4)
Work-related preventive behaviors					
1. How often did you wear a mask at work? (wearing masks at work)	0 (0)	1 (0.5)	12 (6.0)	188 (93.5)	4 (4)
2. How often did you take sick leave if you had respiratory symptoms? (taking sick leave)	61 (30.3)	47 (23.4)	44 (21.9)	49 (24.4)	2 (1–3)
3. How often did you clean your hands with alcohol gel or hand sanitizer after receiving a document from passengers? (cleaning hands during work)	3 (1.5)	14 (7.0)	82 (40.8)	102 (50.7)	4 (3–4)

Note: SD: standard deviation, IQR: interquartile range. †Score has been reversed for mean calculation.

Prevalence of SARS-CoV-2 Antibodies

Participants' antibody results for ELISA and neutralizing assay were all negative for SARS-CoV-2, resulting in a prevalence of SARS-CoV-2 antibodies of zero.

Discussion

According to the results of the behavior survey, wearing a mask at work and in everyday life was the most common preventive behavior, with more than 90% of participants always wearing a mask. This could be a

result of the Thai government's COVID-19 policy, which includes strict social regulations. Since the COVID-19 pandemic, almost every business, grocery store, shopping center, shop and market must prohibit anyone without masks from entering. In the period before COVID-19 occurred, people normally did not wear masks at all.

Conversely, taking sick leave after a respiratory tract infection was the least practice behavior. Immigration officers are entitled to 60 sick leave days annually, with the requirement that a medical certificate be produced. Immigration officers in Thailand serve in day and night shifts. Taking constant sick leave may have consequences on coworkers, even if they are tolerable, which might be a cause for avoiding taking leave. This happened to other types of workers as well. More than half of healthcare workers and other types of workers continued to work while suffering from influenza-like illnesses, which is comparable to results of this study.[10] Some studies found that there was a phenomenon of sickness presenteeism in which workers did not take sick leave despite illness due to economic and social constraints, and workplace culture.[11,12] Other studies described that sickness absenteeism was explained by the workers' perception, disposition, social and cultural standards, and expectations.[13,14] Because of its critical potential in transmitting infections to others and causing new outbreak clusters, the reasons for this high percentage should be explored further using qualitative studies, in-depth interviews, or other-appropriate methods.[15]

Cleaning personal or shared belongings and use of cashless payment systems were the second and third least common preventive behaviors. Both these behaviors are considered to be related to contact transmission. In Thailand, acronyms such as DMHTTA (Distancing, Mask, Hygiene, Testing, Temperature, Application) and VUCA (Vaccine, Universal Prevention, COVID-Free Setting, Antigen Test Kit) were widely promoted, unlike cleaning of personal and shared belongings. Because contact is one of the mechanisms through which SARS-CoV-2 spreads, keeping the environment clean is critical.[16] According to the United Nations International Children's Emergency Fund, the U.S. Centers for Disease Control, and other knowledge-based resource organizations, commonly-touched surfaces such as door knobs, tables, chairs, kitchen and bathroom surfaces, light switches, remote control devices, phones, tablets, computers, and keyboards should be cleaned daily, or at least frequently, using products containing 70% alcohol or bleach.[17–19] For cashless payment systems, according to a poll, 57% of Thai customers utilize digital payment methods (such as debit/credit cards, smartphone apps, mobile banking, and QR codes), compared to 43% who use cash.[20] Due to the long-term tolerance of SARS-CoV-2 on surfaces, a cashless payment system that does not need the exchange of items such as credit cards, is the best approach to encourage physical distancing and limit the contact, thus lowering the risk of contracting and transmitting infectious diseases.[21–24] Even though there is no evidence and scientific support for viral transmission through fomites, fomite contact is still considered to be a possible mode of SARS-CoV-2 transmission.[25,26]

Public Health Recommendation

We suggest that the Ministry of Public Health, in collaboration with the Government Public Relations Department, publicly inform and promote, via media such as television, infographics, and other social media sites and platforms (such as Facebook, YouTube, and Instagram), that people clean their everyday objects such as mobile phones and door knobs, in order to maintain good hygiene. Cashless payment should be encouraged more for both buyers and sellers by media broadcasting. A campaign promoting a tax deduction system for sellers and a discount for buyers using cashless systems may increase its popularity. This could be done through the collaboration of the Ministry of Public Health, the Government Public Relations Department, the Ministry of Finance, and the Ministry of Digital Economy and Society.

Thailand has instituted several safeguard measures to prevent COVID-19 from spreading. People's behavior is one of the most important factors associated with COVID-19 infection. We observed from this study that no immigration police at Don Mueang International Airport had neutralizing antibodies against SARS-CoV-2 infection in May 2020. With the extremely high sensitivity and specificity of the neutralization assay, together the satisfactory process of sample collection, storage, and internal quality control at the laboratory, we believe that the results are accurate, and the participants had not been infected from SARS-CoV-2 previously, since the neutralizing antibody and ELISA titer is mostly detectable for several months among previously infected persons.[7,8,27] This contradicts our prediction that certain immigration officers would be affected as a result of their job, which requires them to interact with a large number of tourists and locals returning from abroad. Another possible reason was that there was a low number of infected international travelers during that period, only 83 cases from 6,424 arrivals in April 2020, or 1.3%.

Limitations

Due to the zero prevalence of SARS-CoV-2 among immigration police, we did not analyze preventive behaviors related to being infected. However, we found behaviors that participants seemed to practice better and worse, and this is useful for health promotion and the development of guidelines at work in order to prevent the spread of disease. Another limitation was that the self-reported questionnaire may have created a response bias. However, we tried to minimize this bias by clarifying the questionnaire to each participant for their better understanding.

Conclusion

After the first wave of the COVID-19 epidemic in Thailand, which occurred between March and April 2020 and in which cases peaked at 188 on 22 March, with a cumulative number of 2,912 cases in these two months, the seroprevalence of SARS-CoV-2 antibodies among 201 Thai immigration police officers working at Don Mueang International Airport was zero, indicating a high likelihood of no previous infection. Wearing a mask at work and in everyday life was the most common preventive behavior, reported by almost all participants. However, taking sick leave while experiencing respiratory infection symptoms was found to be the least practiced behavior. Identifying the reasons behind the reluctance to take sick leave and promoting the importance of taking sick leave while experiencing respiratory infection symptoms will help prevent the spreading of not only SARS-CoV-2 but other infectious viruses.

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Suggested Citation

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References

1. Research and Markets. China outbound tourists visit and spending report 2019 - forecast to 2025 for the $365 billion industry [Internet]. Chicago: PR Newswire; 2019 Sep 25 [cited 2021 Jul 17]. <https://www.prnewswire.com/news-releases/china-outbound-tourists-visit-and-spending-report-2019---forecast-to-2025-for-the-365-billion-industry-300925281.html>
2. Department of Disease Control. Corona Virus Disease 2019 (COVID-19) [Internet]. 2020 [cited 2023 Mar 14]. <https://media.thaigov.go.th/uploads/public_img/source/310364.pdf>
3. Nilsson A, Holm D, Justesen U, Gorm-Jensen T, Andersen N, Ovrehus A, et al. Comparison of six commercially available SARS-CoV-2 antibody assays—choice of assay depends on intended use. Int J Infect Dis. 2021 Feb;103:381–8. doi:10.1016/j.ijid.2020.12.017.
4. Lerdsamran H, Mungaomklang A, Iamsirithaworn S, Prasertsopon J, Prasert K, Intalapaporn P, et al. Evaluation of different platforms for the detection of anti-SARS coronavirus-2 antibodies, Thailand. BMC Infect Dis. 2021 Dec 6;21(1):1213. doi:10.1186/s12879-021-06921-y.
5. Zonneveld R, Jurriaans S, van Gool T, Hofstra J, Hekker T, Defoer P, et al. Head-to-head validation of six immunoassays for SARS-CoV-2 in hospitalized patients. J Clin Virol. 2021 Jun;139:104821. doi:10.1016/j.jcv.2021.104821.
6. Manenti A, Maggetti M, Casa E, Martinuzzi D, Torelli A, Trombetta C, et al. Evaluation of SARS-CoV-2 neutralizing antibodies using a CPE - based colorimetric live virus micro - neutralization assay in human serum samples. J Med Virol. 2020 Oct;92(10):2096–104. doi:10.1002/jmv.25986.
7. Rosadas C, Khan M, Parker E, Marchesin F, Katsanovskaja K, Sureda-Vives M, et al. Detection and quantification of antibody to SARS CoV 2 receptor binding domain provides enhanced sensitivity, specificity and utility. J Virol Methods. 2022 Apr;302:114475. doi:10.1016/j.jviromet.2022.114475.
8. Tan C, Chia W, Qin X, Liu P, Chen M, Tiu C, et al. A SARS-CoV-2 surrogate virus neutralization test based on antibody-mediated blockage of ACE2–spike protein–protein interaction. Nat Biotechnol. 2020 Sep;38(9):1073–8.
9. Luvira V, Leaungwutiwong P, Thippornchai N, Thawornkuno C, Chatchen S, Chancharoenthana W, et al. False positivity of anti-SARS-CoV-2 antibodies in patients with acute tropical diseases in Thailand. Trop Med Infect Dis. 2022 Jul 12;7(7):132. doi:10.3390/tropicalmed7070132.

10. Tartari E, Saris K, Kenters N, Marimuthu K, Widmer A, Collignon P, et al. Not sick enough to worry? "Influenza-like" symptoms and work-related behavior among healthcare workers and other professionals: results of a global survey. PLOS ONE. 2020 May 13;15(5):e0232168. doi:10.1371/journal.pone.0232168.

11. Barnes MC, Buck R, Williams G, Webb K, Aylward M. Beliefs about common health problems and work: A qualitative study. Soc Sci Med. 2008 Aug;67(4):657–65. doi:10.1016/j.socscimed.2008.05.008.

12. Dew K, Keefe V, Small K. 'Choosing' to work when sick: workplace presenteeism. Soc Sci Med. 2005 May;60(10):2273–82. doi:10.1016/j.socscimed.2004.10.022.

13. Bellaby P. What is genuine sickness? the relation between work-discipline and the sick role in a pottery factory. Sociol Health Illn. 1990 Mar;12(1):47–68.

14. Bloor M. Observations of shipboard illness behavior: Work discipline and the sick role in a residential work setting. Qual Health Res. 2005 Jul;15(6):766–77. doi:10.1177/1049732305276735.

15. Pichler S, Wen K, Ziebarth N. COVID-19 Emergency Sick Leave Has Helped Flatten The Curve In The United States. Health Affairs. 2020 Dec;39(12):2197-2204. doi:10.1377/hlthaff.2020.00863.

16. World Health Organization. Transmission of SARS-CoV-2: implications for infection prevention precautions [Internet]. Geneva: World Health Organization; 2020 Jul 9 [cited 2021 Aug 15]. <https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions>

17. National Center for Immunization and Respiratory Disease, Division of Viral Disease. COVID-19 and your health [Internet]. Atlanta (GA): Centers for Disease Control and Prevention (US); 2021 [cited 2021 Aug 15]. <https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html>

18. Cleaning tips to help keep COVID-19 out of your home [Internet]. New York: UNICEF; 2020 Sep 14 [cited 2021 Aug 15]. <https://www.unicef.org/coronavirus/cleaning-and-hygiene-tips-help-keep-coronavirus-covid-19-out-your-home>

19. Tips for keeping COVID-19 out of your home: how cautious should you be about cleaning surfaces and accepting packages? [Internet]. Cleveland (OH): Cleveland Clinic; 2020 Dec 24 [updated 2021 Apr 7, cited 2021 Aug 15]. <https://health.clevelandclinic.org/tips-for-keeping-your-home-clean-in-the-time-of-covid-19/>

20. Banchongduang S. More Thais see cashless future. Bangkok Post [Internet]. 2019 Apr 4 [cited 2021 Sep 26]; Business: [about 2 p.]. <https://www.bangkokpost.com/learning/easy/1656140/more-thais-see-cashless-future>

21. Akter S, Roy P, Ferdaus A, Ibnat H, Alam A, Nigar S, et al. Prevalence and stability of SARS-CoV-2 RNA on Bangladeshi banknotes. Sci Total Environ. 2021 Jul 20;779:146133. doi:10.1016/j.scitotenv.2021.146133.

22. Corpet D. Why does SARS-CoV-2 survive longer on plastic than on paper? Med Hypotheses. 2021 Jan;146:110429. doi:10.1016/j.mehy.2020.110429.

23. Elbadawy H, Khattab A, Alalawi A, Dakilallah Aljohani F, Sundogji H, Mahmoud A, et al. The detection of SARS-CoV-2 in outpatient clinics and public facilities during the COVID-19 pandemic. J Med Virol. 2021 May;93(5):2955–61. doi:10.1002/jmv.26819.

24. Riddell S, Goldie S, Hill A, Eagles D, Drew T. The effect of temperature on persistence of SARS-CoV-2 on common surfaces. Virol J. 2020 Oct 7;17(1):145. doi:10.1186/s12985-020-01418-7.

25. National Center for Immunization and Respiratory Diseases, Division of Viral Diseases. Science Brief: SARS-CoV-2 and surface (fomite) transmission for indoor community environments [Internet]. Atlanta (GA): Centers for Disease Control and Prevention (US); 2021 Mar 24 [updated 2021 Apr 5, cited 2022 Aug 31]. <https://www.cdc.gov/coronavirus/2019-ncov/more/science-and-research/surface-transmission.html>

26. Meister TL, Dreismeier M, Blanco EV, Bruggemann Y, Heinen N, Kampf G, et al. Low risk of severe acute respiratory syndrome coronavirus 2 transmission by fomites: a clinical observational study in highly infectious coronavirus disease 2019 patients. J Infect Dis. 2022 Nov 1;226(9):1608–15. doi:10.1093/infdis/jiac170.

27. Ripperger TJ, Uhrlaub JL, Watanabe M, Wong R, Castaneda Y, Pizzato HA, et al. Orthogonal SARS-CoV-2 serological assays enable surveillance of low-prevalence communities and reveal durable humoral immunity. Immunity. 2020 Nov 17;53(5):925-933.e4. doi:10.1016/j.immuni.2020.10.004.

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Model Development for Reducing Sodium Consumption at the District Level Using a District Health Board Mechanism

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Abstract

High levels of dietary sodium are associated with hypertension and non-communicable diseases. We aimed to develop a model for reducing sodium consumption at the district level using a mechanism developed by the District Health Board (DHB). Hankha District in Chai Nat Province was selected as the study area. The study was conducted between June and December 2022. Research methods included the development of a model to reduce sodium consumption, questionnaires and focus group discussions, and measuring the amount of salt in food and blood pressure levels among study participants. The developed model comprised three measures; monitoring people's sodium consumption; creating a mechanism for driving and managing the environment contributing to behavioral changes; and providing knowledge and promoting behaviors among groups at high risk for hypertension. After model development, the mean knowledge scores among DHB members and their skills in managing plans and projects were significantly higher than those before the process. Mean knowledge scores, health literacy and proper sodium consumption behaviors among at-risk groups were also higher. In addition, the increased knowledge scores significantly correlated with proper sodium consumption behaviors. Our results should encourage authorities at the policy level to apply a DHB mechanism to reduce sodium consumption in communities.

Keywords: model, sodium consumption, District Health Board

Introduction

In Thailand the prevalence of non-communicable diseases such as hypertension, stroke, and diabetes has been increasing each year.[1] The high incidence of these diseases is mainly related to the changing context and structure of Thai society, the economy, and the environment that affect livelihood and health, such as lack of exercise, inappropriate consumption behaviors, and easy access to food. Other related factors include an increase in the amount of spicy, salty and sweet foods, and low consumption of fruit and vegetables.[2] The mean dietary sodium intake in Thailand was estimated to be 3,636 mg/day, which is much higher than the World Health Organization recommendation for adults of 2 g/day (equivalent to 5 g salt/day).[3,4] Several studies demonstrated that reduced sodium intake can lower hypertension and reduce the risk of coronary heart disease, stroke, and chronic kidney disease.[4–7]

In 2018, the Regulations of the Office of the Prime Minister on the establishment of the District Health Board (DHB) were issued with the objective of encouraging participation and integration in developing people's quality of life and health.[8] With a lack of community solutions to reduce people's sodium consumption, researchers developed a logic model as a tool for creating engagement and integration from all sectors.[9–10] This type of model has proven effective in changing alcohol consumption behaviors and for prevention and control of dengue fever.[11–12]

According to the issues selected by the DHB to improve the quality of life of people in Thailand in 2021, a study of the hypertension situation from 2017–2021 indicated that Health Region 3 had the country's highest rate of hypertension per 100,000 population and the highest prevalence of non-communicable diseases and related risk factors.[13] Provincial statistics in Health Region 3 indicated that the morbidity rate of

hypertension per 100,000 population in Chai Nat Province sharply increased from 17,343 in 2017 to 20,533 in 2021.[14–15]

The district level is considered a suitable strategic location for solving chronic health problems that requires long-term solutions. The use of the DHB's mechanism, whereby the district chief is the leader as required by law, would likely be the best solution to the sodium consumption problem. In the past, no study using an appropriate model was conducted to reduce sodium consumption among at-risk groups using the DHB's mechanism. The objective of this study is to develop a model for reducing the sodium consumption of people at risk of hypertension. The findings can be applied and expanded to other areas to prevent and control non-communicable diseases and related risk factors.

Methods

An action research model and purposive sampling method were used in this study. Health Region 3 was selected because of the high prevalence of hypertension among its residents. Selection criteria for districts included: 1) an increase in the morbidity rate of hypertension in the past 5 years, and 2) high rates of non-communicable diseases, notably diabetes and hypertension, in 2021. There were 28 districts that met these two criteria.[13] Hankha District, which consists of eight sub-districts, was randomly selected as the study district.[15] The study was conducted from June to December 2022.

The study sample consisted of two groups. The first group were members of the DHB (age 18 years and over) in Hankha District. We invited 17 people to participate in the study: one district chief, one district public health officer, three representatives of government agencies, two representatives of local administrative organizations and two representatives of sub-district headmen or village headmen, one representative of the private sector, five village health volunteers (VHVs), and two representatives from the community sector.

The second group included members of the community aged 18 years and over, screened by public health officers in 2021 to be at risk of hypertension. The sample size of 18 was based on the formula for a quasi-experimental study design (single group before and after the experiment).[16] However, to account for a 50% drop-out rate, the sample size was increased to 35. Villagers from a list of 1,998 eligible people were randomly selected.

Research Operation: A solution model comprising four steps, as shown in Figure 1, was developed.

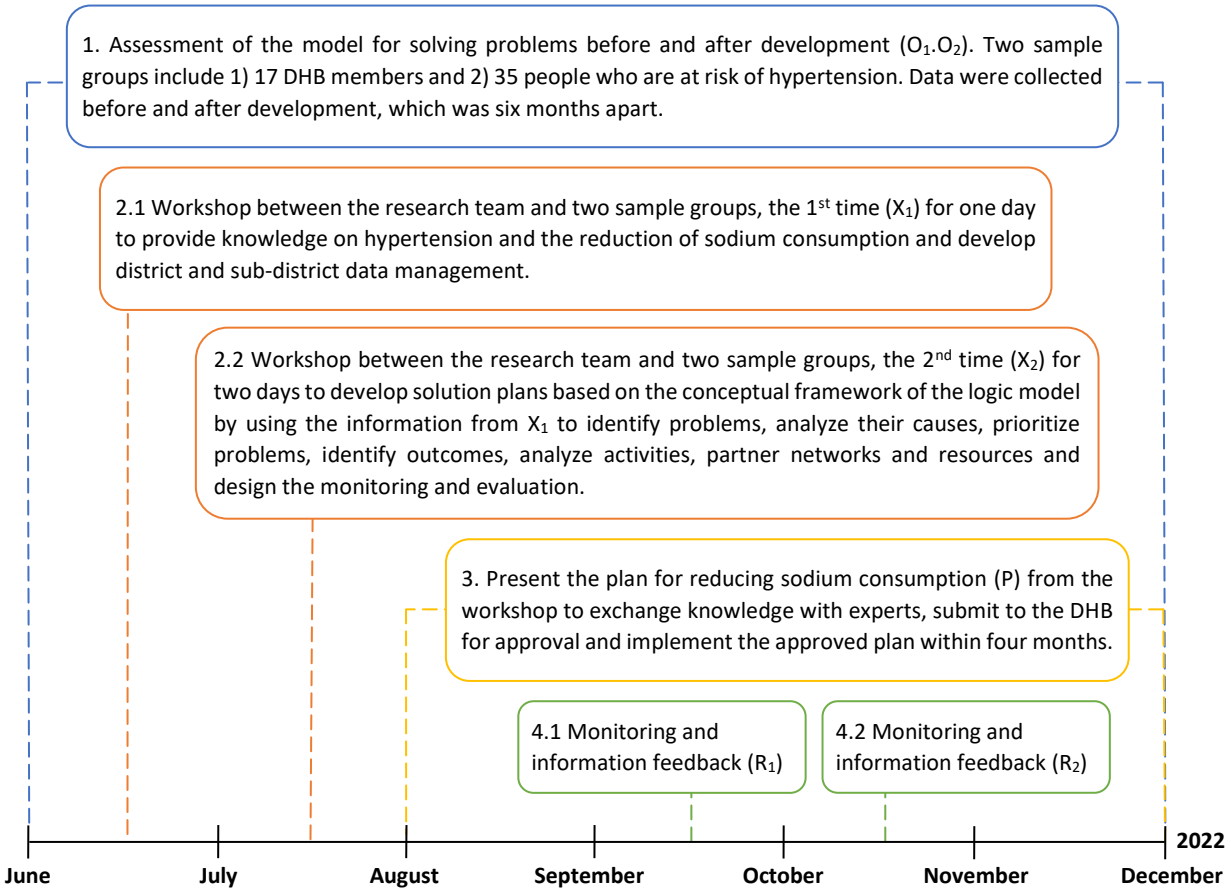

Figure 1. Research procedures of the model development

Data Collection Tools

The tools for the DHB group comprised of 1) a test of their knowledge on project/plan preparation (25 questions with each question worth 1 point), and 2) a plan/project management skills test (10 questions with total scores ranging from 10–50). Items from these two assessments have the Kuder Richardson Formula 20 of 0.84 and 0.82, respectively, based on Cronbach's alpha coefficients.

The tools for the at-risk group included 1) a test of sodium consumption knowledge (10 questions and 30 sub-questions with a total score of 46), 2) an assessment test of health literacy with 22 questions (five parts with scores ranging from 22 to 110), and 3) an assessment of sodium consumption behaviors (nine questions and 31 sub-questions with scores ranging from 0 to 114). Items from the first have the Kuder Richardson Formula 20 of 0.75, second and third assessment forms have Cronbach's alpha coefficients of 0.78 and 0.80, respectively.

Qualitative data on policy development/district solution measures, plan, and project management mechanisms, and project monitoring were collected by focus group discussions among the DHB participants. Solutions for reducing sodium consumption were compared between the project pre-operation and post-operation phases, while knowledge about policies, measures, plans, projects, and activities to reduce sodium consumption, and satisfaction with the proposed methods, were collected from the at-risk group.

Data on the amount of salt consumed was collected using a salt meter.[17] The amount of salt was classified into three levels: 1) low (<275.1 mg sodium/100 mL), 2) medium (275.1–353.7 mg sodium/100 mL), and 3) high (>353.7 mg sodium/100 mL).[18] The data were collected one week prior to the collection of questionnaires on various kinds of foods using the salt meter. Samples were collected from at-risk groups on Monday, Wednesday, and Saturday for three meals a day or a total of nine meals per week.

Blood pressure was measured using a digital blood pressure monitor with standard calibration on the day of questionnaire collection. The two measurements were performed 1–2 minutes apart and the average value was determined.

Statistical Analysis

Data were summarised descriptively using percentages, means, and standard deviations (SD) as appropriate. The paired t-test was used to compare mean scores of knowledge and skills in project/plan management, knowledge of sodium consumption, health literacy, sodium consumption behavior, the difference in mean blood pressure values, and the amount of salt in cooked foods before and after the development of the model. The relationship between knowledge, literacy, and sodium consumption behavior was further determined based on a multiple linear regression model which knowledge and literacy before the development were adjusted. The 95% confidence intervals (CI) or a p-value of <0.05 were used to determine statistical significance. Content analysis was used to analyze the qualitative data.

This study was approved by the Ethics Committee of the Department of Disease Control, FWA 00013622, Code 64058, and by the DHB.

Results

Model for Reducing Sodium Consumption among at-Risk Groups (Part 1)

According to the focus group discussion, attended by 17 members of the DHB group and 35 participants of the at-risk group, a summary of lessons learned from the model development was provided. It was revealed that the participatory problem-solving model of the public, private, and community sectors comprised sodium consumption solution plans and plan driving mechanisms with the following details.

Sodium Consumption Solution Plans

Surveillance of people's sodium consumption behaviors

The first plan comprised the following activities: 1) The DHB, together with the Sub-district Health Board (SHB), VHVs and community leaders, cooperated in developing local data collection tools to be used for surveillance and preparing solution plans, 2) The SHB and all local administrative organizations (LAOs) integrated the district plans approved by the DHB into the sub-district health fund plan and royal health projects, and 3) LAOs support use of salt meters and blood pressure monitors for surveillance of the sodium levels in food and measuring blood pressure levels of the community.

Construction of a driving mechanism and arrangement of an environment

The second plan contributing to behavioral changes consisted of the following activities: 1) the DHB, SHB, VHVs, and community leaders organized a village forum to formulate measures to seek cooperation from food shops and hosts in adapting recipes to reduce sodium intake and reduce the amount of salty foods provided at traditional merit-making ceremonies, 2) sub-district health promoting hospitals (SHPH) provided practical training on the use of salt meters to VHVs, LAOs networks, and food shop operators, and 3)

VHVs set a timeline and publicized how to measure blood pressure levels among all groups of people. Using salt meters to measure the amount of salt in cooked foods in all households by randomly checking various types of foods on Monday, Wednesday and Saturday. This was conducted once a month by one VHV who is responsible for 15 households.

Educating and promoting behaviors of at-risk groups

This plan consisted of the following activities: 1) SHPH provided knowledge to VHVs/community leaders and developed their communication skills to communicate with at-risk groups, 2) VHVs and community leaders applied knowledge to educate people and communicate district policies that promote people to reduce the consumption of sodium in their foods via the village forum, 3) community leaders/VHVs acted as role models, visited at-risk groups, randomly checked foods, measured blood pressure levels, returned the measured salt content in foods and blood pressure levels to raise awareness and encouraged housewives to reduce the amount of salt they add when cooking household meals, and 4) produced social media using community information and launched a communication campaign in the community and shops.

The Mechanism for Driving Plans

It was evident that driving the DHB's sodium consumption solution plans by pushing the reduction of sodium consumption is the DHB's issue. The policy shall be transferred from the district chief to the president of LAOs/sub-district headmen/village headmen. According to the results of the plan operation, the roles of a team at each level are summarized as follows:

The DHB had roles in formulating district policies by selecting the sodium consumption issue as an agenda for improving the quality of life of people, communicating policies and plans through the monthly meetings with heads of government agencies and subdistrict headmen/village headmen, and creating a mechanism for driving SHB and village plans to carry out household activities.

SHB had roles in integrating district plans and sub-district health fund plans/royal public health projects.

LAOs had roles in providing a budget, personnel, and material and equipment, e.g., salt meters and blood pressure monitors.

The roles of the Village Committee, which comprised of sub-district headmen or village headmen, members of LAOs and VHVs, consisted of communicating policies from the district chief, raising awareness, acting as a role model in reducing sodium consumption, visiting at-risk groups, randomly checking foods, measuring blood pressure, returning the information on the amount of salt in foods and blood pressure levels to the participants to raise awareness and encourage them via housewives who prepare household meals.

The SHPH had roles in providing academic support and knowledge of sodium consumption and the use of salt meters in foods to the DHB and the village committee via VHVs, and reporting the results of the operation via the SHB's mechanism and the sodium consumption solution sub-board to submit to the DHB for consideration.

VHVs had roles in providing education and creating awareness in regards to sodium/salt consumption, acting as role models, visiting at-risk groups, randomly checking food, measuring blood pressure levels, returning the measured salt content in foods and blood pressure levels, and encouraging them via housewives to raise awareness, as detailed in Figure 2.

The Results of the Solution Model (Part 2)

In part 2, the results of the solution model were divided according to the two study groups. In the DHB group, of the 17 members, more than half were female (52.9%), and most were aged between 51 and 60 years with an average (standard deviation) age of 48.1 (7.9) and 64.7% had completed a bachelor's degree. Knowledge of plan/project preparation and skills in plan/project management increased significantly after development of the model (Table 1).

Table 1. Comparison of mean scores of the DHB's knowledge on plan/project preparation and management skills before and after model development (n=17)

Variable	Before development		After development		Mean difference (95% CI)	*P*-value
	Mean	SD	Mean	SD		
Knowledge on plan/project preparation	4.59	1.73	17.23	2.75	12.65 (10.94, 14.35)	<0.001
Skills for plan/project management	22.18	9.75	33.12	6.40	10.94 (5.35, 16.53)	<0.001

In the at-risk group, of the 35 participants, two-thirds were female (60.0%) and almost half were aged 41-50 years (42.8%). The average (standard deviation) age was 42.3 (8.0) years. Almost half had either graduated from high school/vocational school (22.9%) or received a diploma/high vocational certificate (22.9%). Most were farmers (65.8%). More than two-thirds received information from public health officers/VHVs (69.1%), followed by online methods such as Line/Facebook/ YouTube/Email (59.5%). Knowledge on sodium consumption and health literacy in

all skills significantly increased after model development (Table 2). Sodium consumption behaviors and salt content in meals were also changed to preferable levels. Blood pressure levels also decreased (Tables 2 and 3).

We found a relationship between knowledge and sodium consumption behaviors (Table 4). However, there was no relationship between health literacy and sodium consumption behavior.

Table 2. Comparison of knowledge, health literacy and sodium consumption behaviors of risk groups before and after model development (n=35)

Variable	Before development		After development		Mean difference (95% CI)	*P*-value
	Mean	SD	Mean	SD		
Knowledge on sodium consumption	28.0	5.38	36.5	5.09	8.51 (6.15, 10.9)	<0.001
Overall health literacy	70.3	17.5	84.2	9.58	13.9 (7.39, 20.4)	0.0001
Data access skills	15.5	5.53	19.3	2.56	3.77 (1.74, 5.80)	0.0006
Understanding skills	13.7	3.35	16.1	1.39	2.46 (1.14, 3.77)	0.0006
Inquiry skills	15.0	4.84	17.8	4.34	2.80 (0.75, 4.84)	0.0088
Decision-making skills	13.3	3.81	16.0	1.54	2.77 (1.43, 4.11)	0.0002
Application skills	12.9	2.43	15.0	2.53	2.11 (1.05, 3.17)	0.0003
Sodium consumption behaviors	61.2	24.9	76.7	32.7	15.6 (1.06, 30.1)	0.0362

Table 3. Comparison of mean sodium levels in consumed or cooked foods and the mean blood pressure before and after model development (n=35)

Variable	Before development		After development		Mean difference (95% CI)	*P*-value
	Mean	SD	Mean	SD		
Amount of sodium in consumed or cooked foods (mg/100 mL)	306.5	86.5	161.1	78.6	-145.4 (-98.2, -176.8)	<0.001
Blood pressure level (mmHg)						
Systolic blood pressure	132.8	5.69	123.5	8.29	-9.31 (-5.33, -13.3)	<0.001
Diastolic blood pressure	84.0	2.97	80.4	4.84	-3.57 (-1.32, -5.82)	0.0028

Table 4. Relationship between sodium consumption knowledge and health literacy with sodium consumption behavior after model development

Characteristic	Number	Mean	SD	Mean difference			*P*-value
				Un-adjusted	Adjusted	95% CI	
Sodium consumption knowledge	35	36.5	5.09	2.60	2.54	0.51, 4.68	0.016
Health literacy	35	84.2	9.58	1.07	1.13	-0.52, 4.68	0.265

Discussion

Following the model development, the DHB determined that the model was successful at reducing sodium consumption, made it a district policy, and formulated a plan for the project at the district level by using a mechanism to drive project plans via the sodium consumption reduction sub-board. Plans transferred from the district level were integrated to the local health assurance fund (sub-district health fund) and royal public health projects subsidized by LAOs. This integration lets communities/villages prepare the sodium consumption solution projects to cover all sub-districts. This may be a result of plans and driving mechanisms from the district policy, whereby the district chief is the leader of the committee that is responsible for driving the plans. This will affect sub-mechanisms at the sub-district level because the district chief is the leader who has authority and duties in accordance with the provincial administration system and indirect power in supervising LAOs.[19] In addition, a key characteristic that is the strength of the DHB's mechanism relates to laws on the establishment of the board consisting of members from the public, private and community sectors. Their roles and duties in solving problems to improve the quality of life of the people were also clearly defined.[8] If the model to reduce sodium consumption is pushed through the DHB's non-communicable disease prevention and control issue based on empirical data, cooperation will be obtained and awareness of the model will be raised.

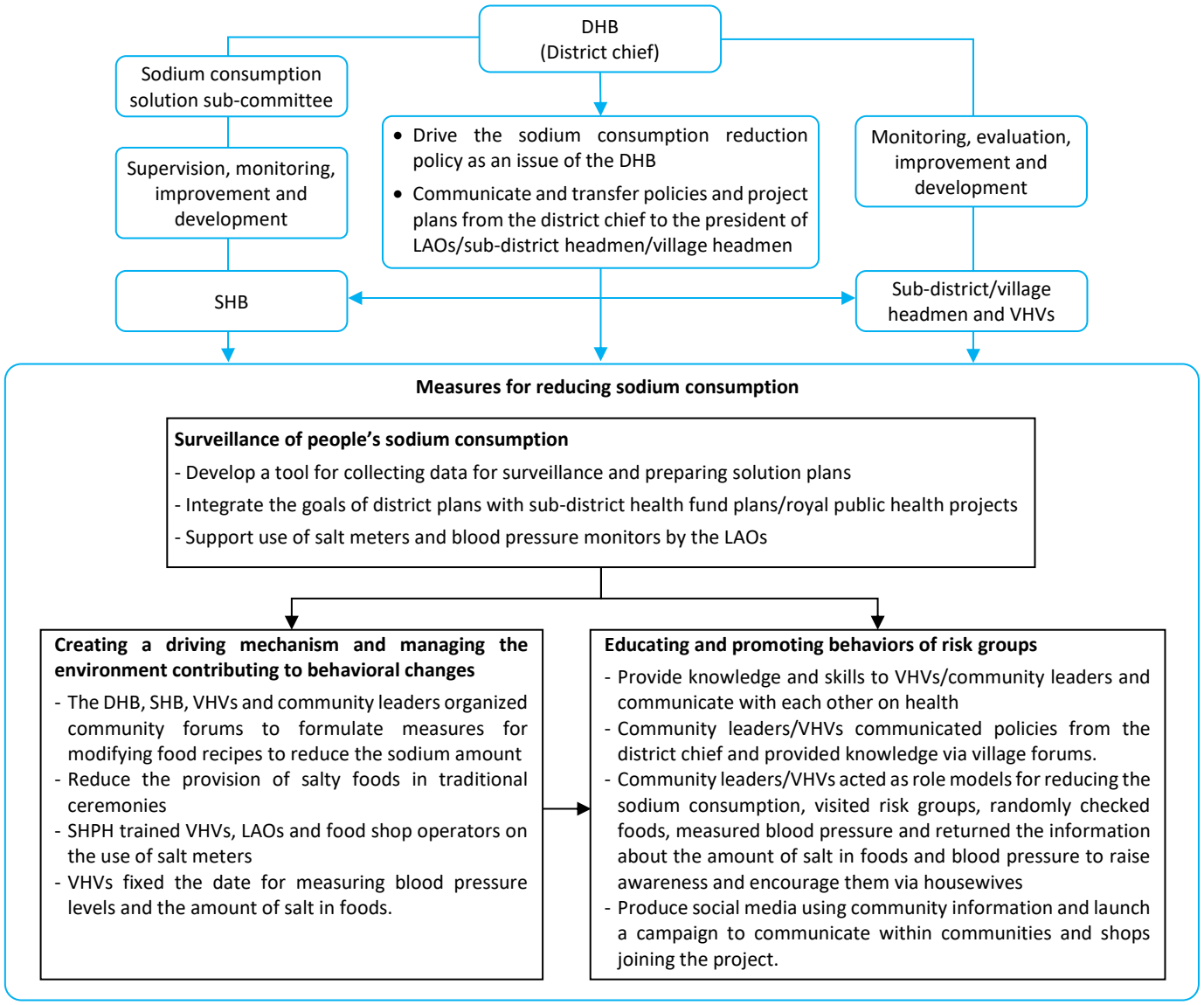

Figure 2. Model for reducing sodium consumption in districts using the DHB's mechanism

Reducing sodium consumption is a difficult behavior to change. However, in the case of communication to raise awareness from the district level through existing mechanisms, e.g., meetings among heads of government agencies, monthly meetings among sub-district headmen and village headmen, and regular reminders, this will eventually raise awareness in the society. The DHB's mechanism will be used to drive sub-district plans to the village. Involvement of VHVs in the project will lead to household changes resulting in changes in solving local problems. This is consistent with the concept of participation which posts that individuals or groups of people must take part in making decisions at different steps on their own, such as joint decision-making, co-development, and benefit-sharing.[20] Quality development for maximum efficiency must, therefore, start from setting common goals to emphasizing participatory operations of public, private, and community sectors through the planning, monitoring, and evaluation process based on all relevant committees.[21] Local information systems should be utilized to assess situations and problems and realize them by means of brainstorming meetings to respond to public needs or necessities. Clear policies and action plans, as well as engagement and strict monitoring, are necessary to enable improvements to quality of life to obtain good outcomes.[22] This is consistent with a study by Khongsateinpong K. who found that communities can be self-reliant because of the operation structure that encourages them to participate in decision-making to create engagement so that they can solve problems quickly.[23]

The analysis of the model developed by the researchers stated that it can enhance skills in managing plans of the health solution scheme. This may be a result of the process of workshop arrangement based on the conceptual framework of the logic model. Following the above-mentioned workshops, the sodium consumption solution plan at the district level was initiated through the participation of the DHB and at-risk groups. During the preparation of plans, the knowledge,

practices, suggestions, and consultations were provided by the research team. This corresponds to studies by Thammakun T. and Prompunjai P. which reported that the application of a logic model to develop a disease prevention and control model enabled the sub-district and district health team to have more knowledge and skills in preparing plans.[11,12]

After the model had been developed, the high-risk groups had better knowledge, better health literacy, and improved sodium consumption behaviors than before. We also found that the knowledge was related to sodium consumption behaviors because the project plans were initiated from the logic model conceptual framework, which was the outcome-based plan. The key activities were related to the knowledge and behavior changes of the at-risk group and consisted of the training and practices of the VHVs/community leaders who can communicate health policies through village forums and act as role models to reduce sodium consumption. In addition, there were also people's sodium consumption surveillance activities and mechanisms for changing the environment that contributes to behavioral changes by DHB, SHB, VHVs, and community leaders.[24–26]

However, we found no relationship between health literacy and sodium consumption behaviors, which is somewhat inconsistent with previous studies and may be explained by the fact that, although the participants had improved health literacy, this literacy may not be applicable for improving their health. However, the development of health literacy on people's sodium consumption, especially in rural areas, leading to their behavioral changes takes time to develop.[27,28] Beside knowledge, health literacy should be assessed and enhanced so that at-risk groups can apply their skills to properly reduce their sodium consumption, thus leading to more sustainable outcomes.

Behavioral changes related to sodium consumption of our participants led to a decreasing amount of salt added in prepared meals and decreasing blood pressure levels of at-risk groups compared to those before model development. This is in line with a study by Mente A et al, which found that the mean systolic blood pressure increased by 2.86 mmHg per 1 g increase in mean sodium intake.[29]

This study has one limitation which should be acknowledged. We used salt meters for measuring sodium intake instead of 24-hour urinary excretion, which is the standard method. However, the measurement of urine sodium excretion has limitations in the community. A further experimental study should be conducted in communities with a comparison group, including the measurement of 24-hour urinary excretion.

Conclusion and Recommendations

The development of a model for reducing sodium consumption among those at risk for hypertension using the DHB's mechanism led to increases in knowledge and health literacy, and improved sodium consumption behaviors. Significant success factors include the use of the district chief's leadership through the roles of the chairman of the DHB plus technical knowledge in formulating and communicating policies, as well as supervising and plan-driving mechanisms. However, without the academic process leading to participation of the DHB in solving community problems, the strengths of the above factors will not be utilized.

To ensure that the model is sustainable, the Ministry of Public Health and the Department of Disease Control, in collaboration with the Institute of Administration Development, Ministry of Interior, should develop problem-solving concepts to allow district chiefs to apply their technical knowledge to solve community problems. Thus, policy units should encourage the DHB to select non-communicable diseases, apply the model for reducing sodium consumption and develop the DHB's knowledge and skills as a mechanism for driving plans. The DHB should also formulate measures for providing education on sodium consumption through community leaders and VHVs and social media so that at-risk groups can apply their skills to change their sodium consumption behavior. This will lead to a reduction in blood pressure levels and, in turn, lower their risk of developing coronary heart disease, stroke and chronic kidney diseases.

Acknowledgments

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References

1. Ministry of Public Health. HDC Dashboard: Non-Communicable diseases reports. [Internet] Nonthaburi: Ministry of Public Health; [cited 2022 Dec 17]. <https://hdcservice.moph.go.th/hdc/reports/page.php?cat_id=6a1fdf282fd28180eed7d1cfe0155e11>. Thai.
2. Office of the National Economic and Social Development Council. Thailand's national strategy B.E. 2561–2581 (2018–2037). Royal Thai Government Gazette. Volume 135, part 82 Kor, (Dated 2018 Oct 13):1.
3. Chailimpamontree W, Kantachuvesiri S, Aekplakorn W, Lappichetpaiboon R, Sripaiboonkij Thokanit N, Vathesatogkit P, et al. Estimated dietary sodium intake in Thailand: A nationwide population survey with 24-hour urine collections. J Clin Hypertens (Greenwich). 2021 Apr;23(4):744–54. [cited 2023 Mar 1]. doi:10.1111/jch.14147.
4. World Health Organization. Guideline: Sodium intake for adults and children [Internet]. Geneva: World Health Organization; 2012 Dec 25 [cited 2022 Dec 25] <https://www.who.int/publications/i/item/9789241504836>
5. Moolphate S. Daily salt intake and factors associated with high salt intake in the community, Donkeaw subdistrict, Chiang Mai province, northern Thailand. Chiang Mai: Chiang Mai Rajabhat University; 2015. 125 p. Thai.
6. Bureau of Non-Communicable, Department of Disease Control. Strategies to reduce salt and sodium consumption in Thailand 2016–2025. 1st ed. Nonthaburi: Bureau of Non-Communicable, Department of Disease Control, Ministry of Public Health (TH); 2016 Oct. 35 p. Thai.
7. Hfocus. Promoting strategies to reduce salt and sodium set a goal for Thai people to reduce salt consumption 30% by 2025 [Internet]. Udon Thani: Hfocus.org; 2019 [cited 2020 Jul 2020]. <https://www.hfocus.org/content/2019/03/16920>. Thai.
8. Office of the Prime Minister. Regulations of the office of the prime minister on the development of quality of life at the local level B.E.2561 (2018). Royal Thai Government Gazette. Volume 135, Special part 54 Ngor. (Dated 2018 Mar 9):1–7.
9. Frechtling J. Logic modeling methods in program evaluation. 8th ed. San Francisco: Jossey-Bass; 2007. 160 p.
10. Helitzer D, Hollis C, de Hernandez BU, Sanders M, Roybal S, Van Deusen I. Evaluation for community-based programs: the integration of logic models and factor analysis. Eval Program Plann. 2010 Aug;33(3):223–33. doi:10.1016/j.evalprogplan.2009.08.005.
11. Thammakun T, Thammakun TH, Prompunjai P, Photipim M, Slawongluk T, Bell O, et al. Application of logic model on development of prevention and behavior modification model of alcohol consumption among youth (PABMACY). Interprof. Journal of Health Science. 2018; 27(3):420–31.
12. Prompunjai P, Thammakun T, Thammakun TH, Pensuk P. Effectiveness of management skill development program for district leaders to prevent dengue hemorrhagic fever in Health Service Network Region 9. Dis Control J. Thailand; 2013;39(3):194–203.
13. Thailand Health Strategic Management Office, Office of the Permanent Secretary, Ministry of Public Health. Information report on diseases and health threats in the management, prevention and control of diseases and health threats with mechanisms to improve the quality of life at the area level. Nonthaburi: Ministry of Public Health; 2021. 82 p. Thai. Non-communicable disease issues operating in 2021.
14. Ministry of Public Health. HDC Dashboard: Data on morbidity rates with high blood pressure [Internet]. Nonthaburi: Ministry of Public Health; 2019 [cited 2021 Aug 1]. <https://hdcservice.moph.go.th/hdc/reports/report.php?&cat_id=6a1fdf282fd28180eed7d1cfe0155e11&id=e46c73b57c9eeb2f07759a9e9bc50fb3>. Thai.
15. Hankha District Public Health Office. Situation survey report on sodium and salt consumption of people in Hankha District, Chai Nat Province, 2022. Chai Nat (TH); Hankha District Public Health Office; 2022 May 25. 30 p. Thai. Meeting documents of the District Health Board.
16. Kaewkungwal J, Singhasivanon P. Sample size in clinical trials. In: Pitisuttithum P, Phichiansunthorn C, editors. Textbook of clinical research. 1st ed. Bangkok: Faculty of Tropical Medicine Mahidol University; 2011. p. 65–72.

17. Wongsawat Y. Development of salt meter in food and urine for Thai health promotion 2017-2018. Nakhon Pathom (TH): Mahidol University; 2018. 34 p. Thai.

18. Vijitsoonthornkul K. Guide to surveying sodium content in foods with a salt meter. Nonthaburi: Division of Non-Communicable Diseases, Department of Disease Control (TH); 2022. 14 p.

19. State Administration Act, B.E. 2534 (1991) (as amended No.8, B.E. 2010) No.108(156). (Dated 1991 Aug 21).

20. Cohen J, Uphoff N. Rural development participation: concept and measure for project design implementation and evaluation: rural development committee center for international studies. New York: Cornell University Press; 1981.

21. Malcolm L, Wright L, Barnett P, Hendry C. Clinical leadership and quality in district health boards in New Zealand. [place unknown]: Clinical Leaders Association of New Zealand; 2002 [cited 2021 Aug 1]. <https://www.moh.govt.nz/notebook/nbbooks.nsf/0/82544E2F11F29181CC256D48007CFBF9/$file/DHBsqualrptfinal.pdf>. 94 p.

22. Vongmanee K, Noosorn N. Lessons learned district health system model for health promotion district in mental health Lomsak District Phetchaboon Province. Journal of Nursing and Health Care. 2017; 35(3):232–41.

23. Khongsateinpong K, Wanaratwichit C. District quality development committee: challenges and development. Bormarajonani College of Nursing, Uttraradit Journal. 2021 Jul–Dec;13(2):275–86.

24. Phetchlamul M. Preventive behavior related to knowledge and perception of hypertension among hypertensive patient's relative. Journal of Public Health Nursing. 2014 Sep–Dec;28(3):175–87.

25. Luenam A, Ngamkham N, Sangsawang D, Pengpanich W, Rattanasuwannachai K, Sengla W, et al. Predictive factor of self-care behavior for prevention of hypertension among population group at risk. HCU Journal of Health Science. 2019 Jun 26;23(1):93–106.

26. Laloon P, Madhyamankura N, Malarat A. Self-care behavior of hypertensive patients at out patient department of HRH Princess Maha Chakri Sirindhorn Medical Center. Journal of Medicine and Health Sciences. 2011 Dec;18(3):160–9.

27. Kareesun K, Malathum P, Sutti N. Relationships among health literacy, Knowledge about hypertension control and health behavior in older person with hypertension. Rama Nurs J. 2019 Sep–Dec;25(3):280–95.

28. Thongma P. Health literacy and health outcome in hypertensive patients. Thai Red Cross Nursing Journal. 2020 Jan–Jun;13(1):50–62.

29. Mente A, O'Donnell M, Rangarajan S, McQueen M, Dagenais G, Wielgosz A. et al. Urinary sodium excretion, blood pressure, cardiovascular disease, and mortality: a community-level prospective epidemiological cohort study. Lancet [Internet]. 2018 Aug 11 [cited 2023 March 1];392(10146):496–506. doi:10.1016/S0140-6736(18)31376-X.

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Risk Factors of COVID-19 Infection and the Effectiveness of Pre-flight Screening from an Investigation of an International Flight to Thailand, 2020

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Abstract

Thailand implemented pre-flight screening (reverse transcription polymerase chain reaction test for SARS-CoV-2 within 72 hours before departure) to mitigate the importation of COVID-19 during the early phase of the pandemic. We conducted a cross-sectional study to identify factors associated with COVID-19 infection and assess the effectiveness of pre-flight screening among passengers on an India-to-Thailand flight in August 2020. Logistic regression was used to determine the association between the possession of COVID-Free Certificate (CFC) and a positive SARS-CoV-2 test result upon arrival. Twenty-three of 209 passengers (11.0%) had a positive SARS-CoV-2 test. Among 142 CFC holders, 10 (7.0%) tested positive, while 13 of 58 (22.4%) passengers without a CFC tested positive upon arrival (*p*-value 0.003), equivalent to a case reduction of 68.8%. CFC possession yielded an adjusted odds ratio (AOR) of 0.04 (95% CI 0.01–0.44). Being a massage therapist (AOR 17.04, 95% CI 2.37–122.37) and using public transportation in India (AOR 5.30, 95% CI 1.49–18.77) were significantly associated with COVID-19 infection. With the unavailability of vaccines, people should be mindful of taking local public transportation during a pandemic, particularly when planning to travel abroad. Pre-flight screening is an effective method in reducing positive cases from international travel.

Keywords: COVID-19, pre-flight screening, SARS-CoV-2

Introduction

In January 2020, Thailand was the first country outside of China to report a case of coronavirus disease 2019 (COVID-19). Soon thereafter the country experienced widespread community transmission.[1] By late August 2020, there were more than 3,400 cases, 16% of which involved international air travel.[2] Air travel has played a critical role in the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) worldwide.[3,4] Strategies to prevent and manage imported cases can be challenging as approximately 80% of infected persons are asymptomatic, yet contagious.[5–9] The spread of SARS-CoV-2 by infected travelers has been previously reported.[10–12] However, there is still limited evidence demonstrating the effectiveness of protective measures for air travel to mitigate SARS-CoV-2 transmission.

Preventive measures amongst air travelers vary from country to country.[13] The World Health Organization has recommended that countries introduce public health measures proportionate to public health risks and conduct up-to-date systematic risk assessments.[14,15] To decrease the number of infected air travelers, many countries have implemented pre-flight screening and testing measures, including screening for COVID-19 signs and symptoms, temperature scanning at airports, requiring proof of a negative reverse transcription polymerase chain reaction (RT-PCR) test from nasopharyngeal or throat swabs before boarding, or a negative rapid-test result upon arrival.

Thailand implemented pre-flight passenger screening for all international flights in March 2020. The measure demanded that all foreign inbound passengers undertake a RT-PCR test 72 hours before departure. Those with a negative RT-PCR test would be provided a COVID-Free Certificate (CFC) before travel as proof of the absence of disease.[16] Thai passengers did not need to undergo this test but were required to undergo a general physical examination by a physician and show flight officers a medical certificate, namely a Fit-to-Fly paper, before boarding as proof of the absence of symptoms.[17] After arrival, all travelers were required to be quarantined at government-regulated quarantine centers, or at government-certified private hotels, for 14 days.[18] After over a year, there was still limited information about the effectiveness of the CFC in preventing SARS-CoV-2 infection during the early stages of the pandemic.

On 8 Aug 2020, the Department of Disease Control (DDC) of the Thai Ministry of Public Health was notified of COVID-19 cases among passengers on a direct flight from India to Thailand. A comprehensive examination of factors related to COVID-19 infection in the context of international traveling was undertaken. The investigation provided an opportunity to examine whether having a CFC was associated with COVID-19 infection upon arrival in Thailand.

Methods

Study Design

During 8–25 Aug 2020, we conducted an investigation of all passengers on an international flight from India to Thailand. We used a cross-sectional study to examine the epidemiological characteristics of the passengers and factors associated with COVID-19 infection, particularly pre-flight screening. We also conducted a brief environmental survey to assess adherence to COVID-19 hygiene regulations on the airplane and at the designated quarantine center.

Operational Definitions

A COVID-19 case was defined as any passenger on the aforementioned flight, 8 Aug 2020, with a positive COVID-19 RT-PCR test result for at least two genes (cycle threshold <40) upon arrival in Thailand.[19] As per the national guideline, specimens were collected twice from passengers during their stay in the quarantine center (days 4–5 for the first round and days 10–14 for the second round). A high-risk contact was defined as any passenger interacting with a confirmed COVID-19 case within a one-meter distance for at least five minutes without proper protective personal equipment (PPE) or sitting within two rows of a COVID-19 case while on board.[20] As all cabin crew members, including flight attendants and pilots, reported wearing proper PPE throughout the flight and tested negative for SARS-CoV-2, they were excluded from this study.

Data Collection and Analysis

Using structured data abstraction and interview forms, we reviewed medical records and conducted phone interviews to collect demographic, clinical, and laboratory information of all passengers on the flight. Additionally, we examined the flight manifest to determine the seating arrangements of all passengers. Data collected included age, gender, nationality, occupation, religion, clinical profile, and laboratory results. More detailed information about risk and protective factors related to COVID-19 infection was collected during follow-up phone interviews. Information on pre-flight history, in-flight history, and seat location on the flight were also collected. Thai or English was used, depending on the language preference of the passenger. Cycle threshold values were assessed to measure the concentration of viral genetic material in the samples by RT-PCR.

The dependent variable was the presence (or absence) of SARS-CoV-2 by RT-PCR test upon arrival in Thailand, in either the first or the second round of testing. The main independent variable was the acquisition of pre-flight screening, a CFC. Other covariates included pre-flight history, in-flight history, and demographic characteristics, as described above. Frequency and proportion were calculated for categorial variables, while median with interquartile range (IQR) was used for continuous variables. Wilcoxon's rank sum test was used to compare the distribution of age between the two groups. Fishers' exact test was used to test for differences in proportions. The Wald test was applied to categorical variables with more than two strata. Independent variables with a p-value <0.1 in the univariable analysis were included in the initial multivariable logistic regression model. Crude odds ratios (OR), adjusted odds ratios (AOR), and 95% confidence intervals (CI) were used to measure the association between CFC and COVID-19 test results upon arrival. All statistical analyses were performed using Stata v14.2 (serial number: 401406358220). Statistical significance was assessed against alpha value 0.05. Multicollinearity was checked using variance inflation factors.

For the environmental survey, we assessed the COVID-19 management in the most populated quarantine facility where the passengers stayed. We also interviewed staff in the quarantine facilities and systematically observed how they performed their routine duties. Information gathered during the survey was assessed based on DDC COVID-19 quarantine guidelines.[21]

Results

Description of the Flight

The flight departed Delhi on 8 Aug 2020 at 12:35 AM and arrived in Thailand at 6:10 PM local time. With the addition of a two-hour waiting time onboard before take-off, the total time that passengers spent on the plane was approximately six hours. Hand sanitization and thermal-scanning were used on all passengers before boarding. There were nine cabin crew and two pilots. The seat occupancy was 88.6% (209 passengers/236 seats). There was no food service on the flight and all passengers were required to wear a face mask at all times.

Demographic, Clinical, and Epidemiologic Characteristics of Passengers

Of the 209 passengers on the flight, 200 were interviewed in person. The majority were Thai (n=126, 63.0%), followed by Indian (n=70, 35.0%). Males (n=105, 52.5%) slightly outnumbered females (n=95, 47.5%), and the median age was 36 years (IQR 26–45). Most (39.0%) were Hindu, followed by Buddhist (33.5%), and Muslim (24.0%). The most common occupations were merchants (22.5%), housewives (15.5%), and students (15.0%) (Table 1).

Twenty-three of the 209 (11.0%) passengers had at least one positive COVID-19 test at arrival, during the first (days 4–5) or the second (days 10–14) round of testing. Of these, 18 tested positive at the airport or during the first round. Among the remaining 191 passengers, 128 were defined as high-risk contacts and 63 were low-risk contacts of the first-round cases. There was no definite clustering pattern shown among cases. The seat positions of cases and contacts on the airplane are shown in Figure 1.

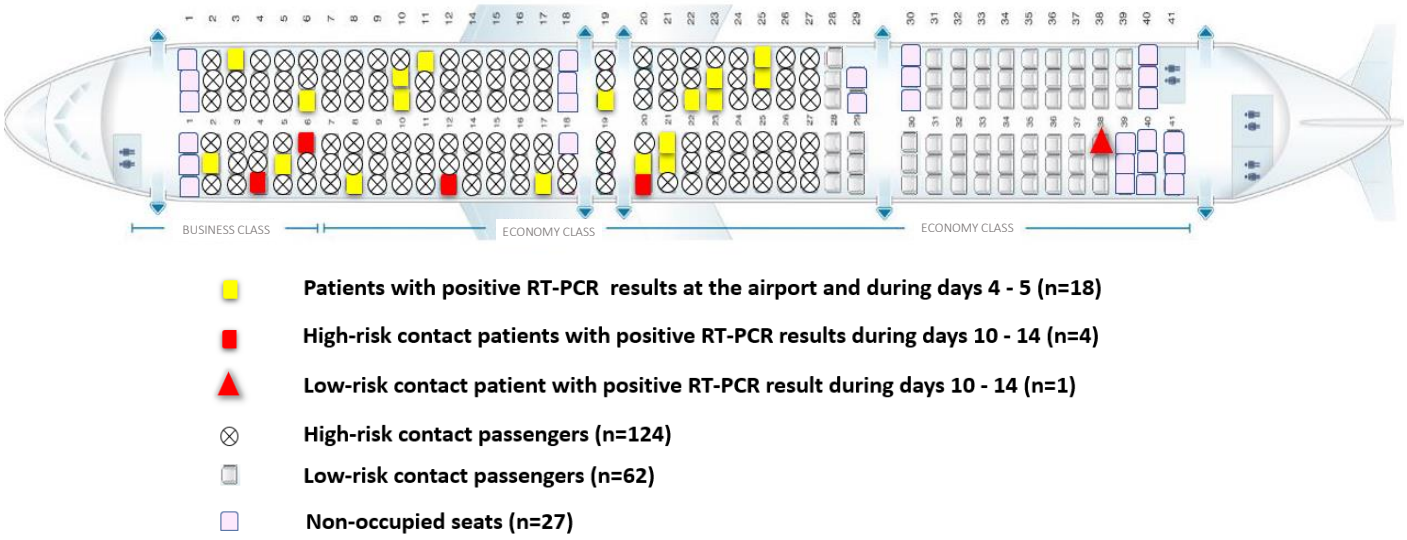

Figure 1. Aircraft seating plan and seat locations of COVID-19 cases detected during days 4–5 or days 10–14 upon arrival in Thailand (n=209)

Approximately three-quarters of cases returned positive results for SARS-CoV-2 within 0–5 days after arrival (1st round including test upon arrival), while the remaining five (21.7%) tested positive during days 10–14 (2nd round), as shown in Figure 2. Overall, cycle threshold values of N gene of SARS-CoV-2 ranged between 16.0–39.5 (median 34.7, IQR 26.9–36.2).

Among 200 passengers who were interviewed, 142 (71.0%) had obtained a CFC before boarding the plane. Of these, ten (7.0%) tested positive for SARS-CoV-2 and eight were detected during the first 4–5 days. Out of the 58 passengers who did not possess a CFC, 13 (22.4%) tested positive for SARS-CoV-2 with two testing positive at the airport, eight within the first 4–5 days and three during the 10-14 days (Figure 2). The reduction in percentage of cases between CFC holders and non-CFC holders was 68.8%. However, the difference in percentage of positive SARS-CoV-2 test between CFC holders and non-CFC holders was not significant in the second round of testing, mainly due to the low sample size.

Ten of the 23 (43.5%) cases were symptomatic and only one case developed pneumonia. All symptomatic patients were asymptomatic before boarding the plane. Among the ten symptomatic patients, seven had coughs and five presented with fever. All symptomatic patients, except the one who developed pneumonia, completely recovered within 14 days without complications. The pneumonia patient recovered within one month. The median duration of symptoms was ten days.

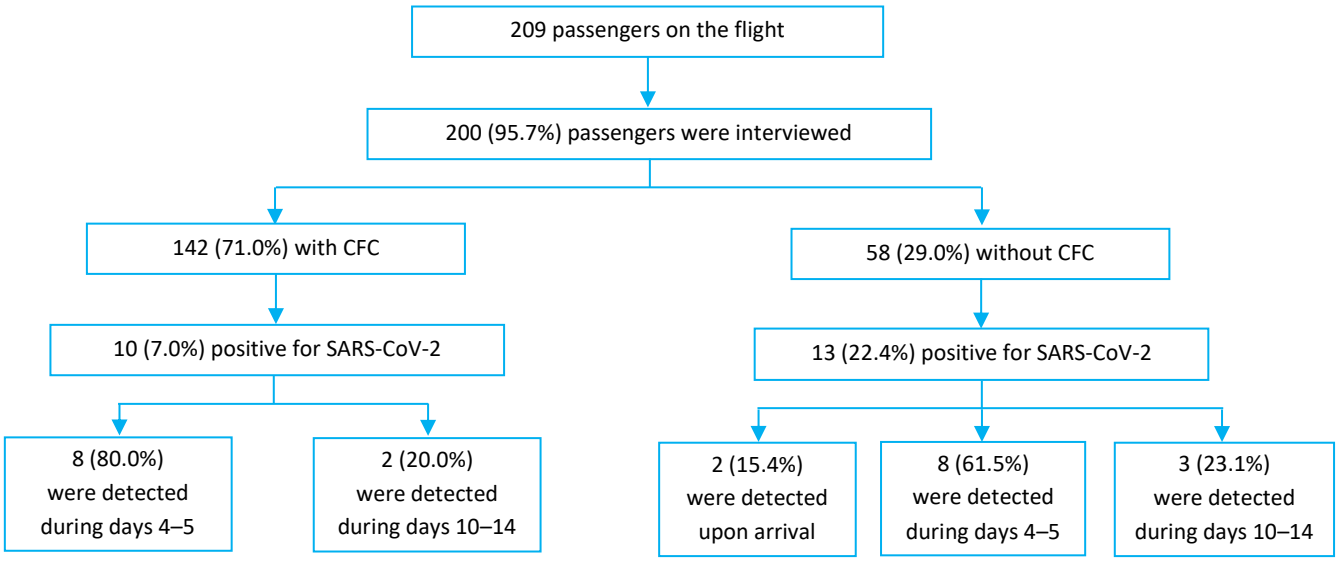

Figure 2. Flowchart showing the distribution of passengers who did and did not obtain a CFC and tested positive for SARS-CoV-2 (n=209)

Univariable and Multivariable Analyses

On univariable analysis, having COVID-19 infection upon arrival in Thailand was significantly associated with being Thai (OR 15.44, 95% CI 2.04–117.13), Buddhist (OR 3.55, 95% CI 1.06–11.89) or Muslim (OR 4.67, 95% CI 1.35–16.12), having a CFC before boarding (OR 0.26, 95% CI 0.11–0.64), and using public transport in India (e.g., bus or train) (OR 4.85, 95% CI 1.62–14.57). Being a massage therapist compared to merchant or others was significantly associated with COVID-19 infection (OR 7.18, 95% CI 1.71–30.26). When comparing being massage therapist to all other occupations, massage therapist also presented a significant association (OR 6.00, 95% CI 1.55–30.17) (Table 1).

Table 1. Univariable analysis determining the association between COVID-19 infection and each independent variable

Variable	COVID-19 positive N=23 n (%)	COVID-19 negative N=177 n (%)	Total passengers N=200 n (%)	OR (95% CI)	*P*-value by Fisher's exact test
Demographic					
Median age (IQR)	35 (28.0-41.0)	36 (25.0-45.0)	-	-	-
Age group (years)					0.467±
≥60	2 (8.7)	12 (6.8)	14 (7.0)	Ref	Ref
1–14	3 (13.0)	28 (15.8)	31 (15.5)	0.64 (0.09–4.35)	0.651
15–19	3 (13.0)	36 (20.3)	39 (19.5)	0.50 (0.07–3.35)	0.476
30–44	13 (56.5)	67 (37.9)	80 (40.0)	1.16 (0.23–5.82)	0.853
45–49	2 (8.7)	34 (19.2)	36 (18.0)	0.35 (0.04–2.79)	0.324
Male	12 (52.2)	93 (52.5)	105 (52.5)	0.99 (0.41–2.35)	0.973
Thai	22 (95.7)	104 (58.8)	126 (63.0)	15.44 (2.04–117.13)	0.008
Religion					0.044±
Hindu or others	4 (17.4)	81 (45.8)	85 (42.5)	Ref	Ref
Buddhist	10 (43.5)	57 (32.2)	67 (33.5)	3.55 (1.06–11.89)	0.040
Muslim	9 (39.1)	39 (22.0)	48 (24.0)	4.67 (1.35–16.12)	0.015
Occupation#					0.113±
Merchant or others	9 (39.1)	97 (54.8)	106 (53.0)	Ref	Ref
Massage therapist	4 (17.4)	6 (3.4)	10 (5.0)	7.18 (1.71–30.26)	0.007
Housewife	3 (13.0)	28 (15.8)	31 (15.5)	1.15 (0.29–4.56)	0.837
Student	4 (17.4)	26 (14.7)	30 (15.0)	1.66 (0.47–5.81)	0.430
Employee	3 (13.0)	20 (11.3)	23 (11.5)	1.62 (0.40–6.51)	0.500
Documentation of RT-PCR for SARS-CoV-2 negative before boarding					
Pre-flight screening (CFC)	10 (43.5)	132 (74.6)	142 (71.0)	0.26 (0.11–0.64)	0.003

Table 1. Univariable analysis determining the association between COVID-19 infection and each independent variable (cont.)

Variable	COVID-19 positive N=23 n (%)	COVID-19 negative N=177 n (%)	Total passengers N=200 n (%)	OR (95% CI)	*P*-value by Fisher's exact test
Symptoms and laboratory result					
Having symptoms	10 (43.5)	3 (1.7)	13 (6.5)	44.62 (10.92–182.36)	<0.001
Cough	7 (30.4)	1 (0.6)	8 (4.0)	77.00 (8.91–665.60)	<0.001
Fever	5 (21.7)	0 (0)	5 (2.5)	NA	NA
Rhinorrhea	4 (17.4)	2 (1.1)	6 (3.0)	18.42 (3.16–107.30)	0.001
Anosmia	3 (13.0)	0 (0)	3 (1.5)	NA	NA
Sore throat	3 (13.0)	0 (0)	3 (1.5)	NA	NA
Myalgia	3 (13.0)	0 (0)	3 (1.5)	NA	NA
Phlegm	2 (8.7)	0 (0)	2 (1.0)	NA	NA
Diarrhea	1 (4.4)	0 (0)	1 (0.5)	NA	NA
Pneumonia	1 (4.4)	0 (0)	1 (0.5)	NA	NA
Pre-departure behavior (2 weeks before boarding)					
Visiting a mosque	8 (34.8)	31 (17.5)	39 (19.5)	2.51 (0.97–6.44)	0.055
Using public transportation	6 (26.1)	12 (6.8)	18 (9.0)	4.85 (1.62–14.57)	0.005
Not always wearing a mask while going outside	4 (17.4)	0 (0)	4 (2.0)	NA	NA
In-flight behavior					
Not wearing a mask all the time	0 (0)	2 (1.1)	2 (1.0)	NA	NA
Not using hand sanitizer	0 (0)	9 (5.1)	9 (4.5)	NA	NA
Seat swapping	0 (0)	3 (1.6)	3 (1.5)	NA	NA

Note: NA denotes "not applicable" as the software failed to determine the strength of association due to perfect prediction.
‡P-value by Wald test. #Being a massage therapist compared to all other occupations, show OR of 6.00 (95% CI 1.55-30.17).
CFC: COVID-19-free certificate, IQR: interquartile range, OR: crude odds ratio, CI: confidence interval, Ref: reference group

On multivariable analysis, CFC possession was negatively associated with COVID-19 infection (AOR 0.04, 95% CI 0.01–0.44). Working as massage therapist during COVID-19 pandemic (AOR 17.04, 95% CI 2.37-122.37), and use of public transportation in India was significantly associated with COVID-19 infection (AOR 5.30, 95% CI 1.49–18.77). There was no multicollinearity among nationality, religion, and visiting a mosque (variance inflation factors=2.3, 2.31, and 1.18 respectively) (Table 2).

Table 2. Multivariable analysis determining the association between COVID-19 infection and selected independent variables

Independent variables	AOR	95% CI
Thai	4.69	0.47–46.83
Religion		
Hindu or others	Ref	Ref
Buddhist	0.40	0.08–1.97
Muslim	6.42	0.24–172.10
Massage therapist	17.04	2.37–122.37
CFC possession	0.04	0.01–0.44
Visiting a mosque within 2 weeks before departure	2.01	0.20–20.22
Using public transportation within 2 weeks before departure	5.30	1.49–18.77

Note: CFC: COVID-19-free certificate, AOR: adjusted odds ratio, CI: confidence interval, Ref: reference group

Environmental Survey

We visited the main quarantine facility where 142 passengers stayed to assess the risk of post-arrival infection and hygiene standards. We found that all quarantine staff strictly followed guidelines stipulated by the DDC during the period of the passengers' stay.[21] Cleaning staff were prohibited from entering passengers' rooms and guests were not allowed to leave their rooms. The video coverage showed no transgression of the regulations. Medical and cleaning staff were regularly trained on PPE application and removal.

Discussion

Our findings suggest that pre-flight screening with a CFC, in the context when a COVID-19 vaccine was unavailable, effectively prevented COVID-19 infections among international visitors and returnees. The odds of testing positive for COVID-19 after arrival amongst non-CFC-holders was 25 times as large as the odds amongst CFC holders. A simulation study by Kiang et al suggested that the pre-travel RT-PCR test (within three days before boarding) reduced the number of infectious days by 36% and could identify approximately 88.0% of the actively infectious travelers.[22]

Our study found that the case reduction percentage of pre-flight screening was 68.8%, potentially preventing COVID-19 importation to Thailand. Despite limited evidence of the exact case reduction percentage of pre-flight screening in other countries, during 6 Jun to 14 Nov 2020, SARS-CoV-2 testing on arrival in Alaska airports identified 951 SARS-CoV-2 infections, or one per 406 arriving travelers, which might have contributed to Alaska's low incidence during summer.[12]

The quarantine measure after arrival should continue regardless of the possession of CFC given vaccine unavailability. This is because, based on our findings, about 7.0% of CFC holders were still found positive for SARS-CoV-2 after arrival. A possible explanation for this is that the incubation period of COVID-19 can range from 2–14 days and extend to 24 days in a few extreme settings.[23] For this reason, it is necessary to deliver the quarantine measure for all cross-country visitors and returnees. During the period of investigation, many countries such as Canada and the United Kingdom still imposed quarantine measures on travelers regardless of the RT-PCR result before departure.[24,25]

Our study found that massage therapists are at risk of COVID-19 infection. It is because they might be in close contact with clients and may encounter respiratory droplets or other bodily fluids.[26–28] A study in Norway found similar results. It showed individuals employed as physiotherapists had two times the odds of COVID-19 infection during the first wave of infection compared to every one of their working age.[29]

Showed in our study, using public transportation in India during the early phase of the pandemic before departure is associated with positive SARS-CoV-2. Consistent with a large prospective cohort in Norway, people with COVID-19 infection were more likely to be using public transport than those who were not getting an infection.[30] Moreover, during the early pandemic in China, COVID-19 transmission was also detected on bus travel.[31]

Regarding infection risk, cases were likely to be infected before they left India. Supporting evidence included the fact that, at that time, the COVID-19 situation in India was pronounced, and the multivariable analysis found a strong association of working as massage therapist and a history of public transport use in India with positive SARS-CoV-2.[32] In contrast, other factors such as religion and nationality were not significant. Evidence of disease transmission on board the plane and at the quarantine center could not be found. This is probably because all cabin crew and staff at the quarantine center complied with the protocols, and there was no clear clustering pattern in terms of the flight seats amongst the cases. The environment in the quarantine center was also well-managed.

This study contained both strengths and limitations. In terms of strengths, we were able to obtain information from almost all passengers on the flight. Additionally, we exercised various data collection methods including interviews and observations. However, some limitations remained. Firstly, as the study was part of the DDC's routine investigation, which required only RT-PCR test for disease screening, we did not perform a whole genome study to prove if the viral clade of the cases matched the clade prevailing in India. Therefore, our suggestion that the cases were infected with SARS-CoV-2 in India was only speculative. Secondly, as some interview topics were about history, recall bias was inevitable. However, the history we explored was quite recent, thus any recall bias would be minimal, and would not severely affect the validity of the findings. Thirdly, since the interviews were conducted in English for non-Thai participants (who were mostly Indian), there might be some degree of language misunderstanding or varying interpretations across passengers. However, this factor might not hugely undermine the findings as most of the interview questions were not complicate. Lastly, this study was not free from social desirability bias when we interviewed the participants or observed the management of the quarantine center. The research team did not have enough time to stay and observe the actual practice of the staff of the quarantine center. Nonetheless, we exercised multiple data collection techniques to triangulate the findings.

Conclusion and Recommendations

This study revealed that the pre-flight CFC acquisition helped mitigate the risk of COVID-19 infection after arrival more than half. Other key risk factors included

working as massage therapist and using public transport in India. The risk of infection on board and in the quarantine center was minimal. Concerning recommendations, the quarantine measure should continue for all visiting travelers and Thai returnees regardless of the possession of a CFC. Maintaining the CFC policy for unvaccinated people as long as the ongoing pandemic should be considered. An emphasizing message for travelers visiting other countries to avoid public transport and consider a temporary pause of working in close contact with other people, such as massage therapists, during the early stages of a pandemic should be delivered.

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Author Contributions

Conceptualization: KS, and RS; Methodology: KS, and RS; Formal analysis: KS and RS; Investigation: KS, TC, PP, and NS; Writing—original draft: KS, and RS; Writing—review and editing: KS, and RS; Supervision: RS.

Declaration of Conflict of Interest

The author(s) declare no conflicts of interest.

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Ethics Approval

This study was part of the disease investigation operation under the Department of Disease Control of the Ministry of Public Health. Therefore, ethics approval was not needed. However, the authors strictly followed the ethical standards for research and publication. Individual data were kept strictly confidential.

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References

1. Jasarevic T, Chaib F. WHO statement on novel coronavirus in Thailand [Internet]. Geneva: World Health Organization; 2020 Jan 13 [cited 2021 Apr 12]. <https://www.who.int/news/item/13-01-2020-who-statement-on-novel-coronavirus-in-thailand>
2. Department of Disease Control, Ministry of Public Health (TH). Daily COVID-19 report [dataset on the Internet]. Bangkok: Digital Government Development Agency; 2020 Mar 20 [cited 2020 Nov 29]. <https://data.go.th/dataset/covid-19-daily>. Thai.
3. Grout A, Howard N, Coker R, Speakman EM. Guidelines, law, and governance: disconnects in the global control of airline-associated infectious diseases. Lancet Infect Dis [Internet]. 2017 Apr [cited 2020 Nov 27];17(4):e118–22. doi:10.1016/S1473-3099(16)30476-5.
4. Hsu CI, Shih HH. Transmission and control of an emerging influenza pandemic in a small-world airline network. Accid Anal Prev [Internet]. 2010 Jan [cited 2020 Nov 29]; 42(1):93–100. doi:10.1016/j.aap.2009.07.004.
5. Luo SH, Liu W, Liu ZJ, Zheng XY, Hong CX, Liu ZR, et al. A confirmed asymptomatic carrier of 2019 novel coronavirus. Chin Med J (Engl) [Internet]. 2020 May 5 [cited 2021 Mar 23];133 (9):1123–5. <https://journals.lww.com/10.1097/CM9.0000000000000798>.
6. Kimball A, Hatfield KM, Arons M, James A, Taylor J, Spicer K, et al. Asymptomatic and presymptomatic SARS-CoV-2 infections in residents of a long-term care skilled nursing facility — King County, Washington, March 2020. MMWR Morb Mortal Wkly Rep [Internet]. 2020 Apr 3 [cited 2021 Mar 23]; 69(13):377–81. doi:10.15585/mmwr.mm6913e1.
7. Qian G, Yang N, Ma AHY, Wang L, Li G, Chen X, et al. COVID-19 transmission within a family cluster by presymptomatic carriers in China. Clin Infect Dis [Internet]. 2020 Aug 1 [cited 2021 Mar 23];71(15):861–2. doi:10.1093/cid/ciaa316.
8. Mizumoto K, Kagaya K, Zarebski A, Chowell G. Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020. Euro Surveill [Internet]. 2020 Mar [cited 2021 Mar 23];

25(10):2000180. doi:10.2807/1560-7917.ES.2020.25.10.2000180.

9. Yanes-Lane M, Winters N, Fregonese F, Bastos M, Perlman-Arrow S, Campbell JR, et al. Proportion of asymptomatic infection among COVID-19 positive persons and their transmission potential: A systematic review and meta-analysis. PLoS One [Internet]. 2020 Nov 3 [cited 2021 Mar 23];15(11):e0241536. doi:10.1371/journal.pone.0241536.

10. Myers JF, Snyder RE, Porse CC, Tecle S, Lowenthal P, Danforth ME, et al. Identification and monitoring of international travelers during the initial phase of an outbreak of COVID-19 — California, February 3–March 17, 2020. MMWR Morb Mortal Wkly Rep [Internet]. 2020 May 15 [cited 2020 Nov 29];69(19):599–602. doi:10.15585/mmwr.mm6919e4.

11. Sotomayor-Castillo C, Radford K, Li C, Nahidi S, Shaban RZ. Air travel in a COVID-19 world: commercial airline passengers' health concerns and attitudes towards infection prevention and disease control measures. Infect Dis Health [Internet]. 2021 May [cited 2020 Nov 29]; 26(2):110–7. doi: 10.1016/j.idh.2020.11.002.

12. Ohlsen EC, Porter KA, Mooring E, Cutchins C, Zink A, Mclaughlin J. Morbidity and mortality weekly report airport traveler testing program for SARS-CoV-2-Alaska, June-November 2020. MMWR Morb Mortal Wkly Rep. 2021 Apr 23 [cited 2021 Jul 19];70(16):583–8. doi:10.15585/mmwr.mm7016a2.

13. Department of State (US). COVID-19 country specific information [Internet]. Washington: Travel.State.Gov; [cited 2021 Jul 19]. <https://travel.state.gov/content/travel/en/traveladvisories/COVID-19-Country-Specific-Information.html>

14. International Civil Aviation Organization. Joint statement: joint ICAO-WHO statement on COVID-19 [Internet]. Montreal (QC): International Civil Aviation Organization; [cited 2021 Dec 24]. 2 p. <https://www.icao.int/Security/COVID-19/Pages/Statements.aspx>

15. World Health Organization. Considerations for implementing a risk-based approach to international travel in the context of COVID-19 [Internet]. Geneva: World Health Organization; 2020 Dec 16 [cited 2021 Jul 19]. <https://www.who.int/news-room/articles-detail/considerations-for-implementing-a-risk-based-approach-to-international-travel-in-the-context-of-covid-19>

16. Royal Thai Embassy in New Delhi. Announcement guidelines for foreign nationals travelling to Thailand during COVID-19 pandemic [Internet]. New Delhi: Royal Thai Embassy in New Delhi; [cited 2021 Apr 12]. <http://newdelhi.thaiembassy.org/en/2020/03/announcement-guidelines-foreign-nationals-travelling-thailand-covid-19-pandemic/>

17. Royal Thai Embassy in New Delhi. Announcement of the Royal Thai Embassy in New Delhi No. 9/2020 subject requesting cooperation from Thai people who wish to return to Thailand during the situation of the new strain of coronary infection (COVID-19) [Internet]. New Delhi: Royal Thai Embassy in New Delhi; 2020 Apr 2 [cited 2020 Dec 10]. 2 p. <http://newdelhi.thaiembassy.org/th/2020/04/ประกาศสถานเอกอัครราชทู-4/>. Thai.

18. Department of Disease Control (TH). Measures to control COVID-19. Version 5. Nonthaburi: Department of Disease Control (TH); 2020 Apr 2. 2 p.

19. Zhang X, Li M, Zhang B, Chen T, Lv D, Xia P, et al. The N gene of SARS-CoV-2 was the main positive component in repositive samples from a cohort of COVID-19 patients in Wuhan, China. Clin Chim Acta [Internet]. 2020 Dec [cited 2020 Dec 6];511:291–7. doi: 10.1016/j.cca.2020.10.019.

20. Department of Disease Control, Ministry of Public Heath (TH). Guidelines for surveillance and investigation of coronavirus disease 2019 (COVID-19). Nonthaburi: Department of Disease Control (TH);2020 May 15. p. 1–41. Thai.

21. Guidelines for the management of the area of state quarantine integrated [Internet]. Version 2.0. Nonthaburi: Department of Disease Control (TH); 2020 Jul 21 [cited 2020 Nov 30]. <https://ddc.moph.go.th/viralpneumonia/file/g_quarantine/g_quarantine_state210763n.pdf>

22. Kiang MV, Chin ET, Huynh BQ, Chapman LAC, Rodriguez-Barraquer I, Greenhouse B, et al. Routine asymptomatic testing strategies for airline travel during the COVID-19 pandemic: a simulation study. Lancet Infect Dis [Internet]. 2021 Jul [cited 2021 Apr 4];21(7):929–38. doi:10.1016/S1473-3099(21)00134-1.

23. Harapan H, Itoh N, Yufika A, Winardi W, Keam S, Te H, et al. Coronavirus disease 2019 (COVID-19): A literature review. J Infect Public Health [Internet]. 2020 May [cited 2020 Dec 4]; 13(5):667–73. doi:10.1016/j.jiph.2020.03.019.

24. GOV.UK. How to quarantine when you arrive in England [Internet]. London; Government Digital Service, part of the Cabinet Office (GB): [cited 2021 Apr 13]. <https://www.gov.uk/guidance/how-to-quarantine-when-you-arrive-in-england>

25. Travel.gc.ca. Mandatory quarantine or isolation – Travel restrictions in Canada – [Internet]. [cited 2021 Apr 13]. <https://travel.gc.ca/travel-covid/travel-restrictions/isolation>

26. Lotfi M, Hamblin MR, Rezaei N. COVID-19: transmission, prevention, and potential therapeutic opportunities. Clin Chim Acta [Internet]. 2020 Sep [cited 2023 Mar 26];508:254–66. doi:10.1016/j.cca.2020.05.044.

27. Stadnytskyi V, Bax CE, Bax A, Anfinrud P. The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission. Proc Natl Acad Sci U S A. 2020 Jun 2;117(22):11875–7. doi:10.1073/pnas.2006874117.

28. Liu Y, Ning Z, Chen Y, Guo M, Liu Y, Gali NK, et al. Aerodynamic Characteristics and RNA Concentration of SARS-CoV-2 Aerosol in Wuhan Hospitals during COVID-19 Outbreak. bioRxiv 2020.03.08.982637 [Preprint]. 2020 Mar 10 [cited 2023 Mar 26]. <https://www.biorxiv.org/content/10.1101/2020.03.08.982637v1>

29. Magnusson K, Nygard K, Methi F, Vold L, Telle K. Occupational risk of COVID-19 in the first versus second epidemic wave in Norway, 2020. Euro Surveill [Internet]. 2021 Oct [cited 2023 Mar 26];26(40):pii=2001875. doi:10.2807/1560-7917.ES.2021.26.40.2001875.

30. Ellingjord-Dale M, Kalleberg KT, Istre MS, Nygaard AB, Brunvoll SH, Eggesbo LM, et al. The use of public transport and contraction of SARS-CoV-2 in a large prospective cohort in Norway. BMC Infect Dis [Internet]. 2022 Mar 14 [cited 2023 Mar 26];22(1):252. <https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-022-07233-5>

31. Shen Y, Li C, Dong H, Wang Z, Martinez L, Sun Z, et al. Community outbreak investigation of SARS-CoV-2 Transmission Among Bus Riders in Eastern China. JAMA Intern Med [Internet]. 2020 Dec 1 [cited 2023 Mar 26];180(12):1665–71. doi:10.1001/jamainternmed.2020.5225.

32. WHO Country Office for India. Novel coronavirus disease (COVID-19): India Situation report–28 [Internet]. New Delhi: Office of the WHO Representative in India; 2020 Aug 10 [cited 2020 Nov 29]. 3 p. <https://www.who.int/docs/default-source/wrindia/situation-report/india-situation-report-28.pdf?sfvrsn=d3de032_2>

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The Grammar of Science: How "Good" is Your Instrument?

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In order to answer a research question. the researchers have to design or select the appropriate research instrument(s) or measurement tool(s) to obtain the data related to the objective(s) of the study. Research instruments are in different formats, techniques, or methods including, but not limited to, questionnaires, clinical interviews, laboratory tests, etc. When the researchers want to measure something especially the attributes that can't be observed directly (e.g., quality of life, attitude) they have to define observable or measurable indicators to measure those attributes. Such concrete indicators are considered as constructs (aka components, dimensions, or factors) of the attribute being measured. A questionnaire is defined as an instrument for the measurement of one or more concepts or constructs which are generally resulted in aggregated item scores/scales.[1] An interview could be completely structured similar to questionnaire or an open-ended statements, questions, or stimulus word to obtain responses given by the target study population.[1] Laboratory tests involve medical procedures that examine a sample of blood, urine, or other substance from the body; the test results will be used to answer the research questions in terms of determining diagnosis, checking to see if treatment is working, or monitoring the disease over time.[2]

What Determine "Good" Quality of a Research Instrument?

The ability of a research instrument to measure the constructs under study's objectives is a vital factor in selecting or applying the instrument. The qualities of a good research instrument are (1) validity and (2) reliability. Validity and reliability are concepts used to indicate how well a method, technique or test measures something.[1,3,4] Reliability is the extent to which the measurements is dependable, self-consistent, stable and/or reproduceable when repeating under the same conditions. Validity is the extent to which the results really measure what they are supposed to measure.[3]

At this time, let's focus on the quality of a structured or unstructured questionnaire/interview developed for use in a research study. For this kind of research instrument, the researchers should consider, at the minimum, attaining "content validity" and "internal consistency" of the measurement. Content validity means the extent to which the content or topic in the instrument is truly representative of all aspects of the concept(s) or construct(s) it is designed to measure.[5] Internal consistency reliability defines the consistency of the results delivered from the measurement tool, ensuring that the various items measuring the topic(s) of interest deliver consistent responses/scores.[6]

"Content Validity"—Do You Measure the Concept(s) that You Want to Measure?

In fact, there are three common types of validity including content, construct, and criterion-related validity. Content validity is considered as a prerequisite for other validity and usually receives the highest priority in development process of a questionnaire/interview forms.[7]

Content validity is also known as definition validity or logical validity.[7] Content validity tells us how "good" the instrument is at measuring a concept. A similar idea of content validity is "Face validity" which also employs similar approach by assigning a panel of experts to use their theoretical and substantive knowledge and respond to each item whether or not it is or is not a good item.[8] However, face validity indicates that the measure appears to be valid "on its face" while content validity requires a more rigorous process, such as using a panel of experts to evaluate the logical content within the concept to be measured.[9] Steps in evaluating content validity are as follow:[7,10–12]

Step 1: Determine the Content—Identification of Concept/Construct and Item Generation

The first step is determining the content of the concept(s) or construct(s) that the instrument intends to measure. The content can be identified by literature review and/or focus group discussion or interview with the people familiar with concept. To make it manageable, a "Table of Specifications" of the content for each concept should be created. The researchers then develop items based on the table of specification. When measuring data related to behavior, feeling, or certain action that cannot be captured in a single variable or item, it is recommended to develop multiple items in consideration of measurement error and gaining more accurate responses.[12] A sample of table of specifications adopted from part of the WHOQOL instrument (measuring quality of life) composes of two constructs: physical health and psychological health.[13] Two items are developed for the three topics (content) of each construct (Table 1). In evaluating the content validity of this instrument, the researchers may assess the content validity of each construct separately and/or the entire instrument that intends to measure quality of life.

Table 1. Example of table of specification for quality of life instrument

Concepts/Constructs	Items
Physical Health	
I. Pain and discomfort	1. Do you worry about your pain or discomfort?
	2. How difficult is it for you to handle any pain or discomfort?
II. Energy and fatigue	3. How easily do you get tired?
	4. How much are you bothered by fatigue?
III. Sleep and rest	5. Do you have any difficulties with sleeping?
	6. How much do any sleep problems worry you?
Psychological Health	
I. Positive feelings	1. How much do you enjoy life?
	2. How much do you experience positive feelings in your life?
II. Self-esteem	3. How much do you value yourself?
	4. How much confidence do you have in yourself?
III. Bodily image and appearance	5. Do you feel inhibited by your looks?
	6. Is there any part of your appearance which makes you feel uncomfortable?

Note: Examples of concepts and items adopted from WHOQOL-100 Instrument.

Step 2: Judgment by Expert Panel—Appointment and Consensus of the Experts' Opinions

To confirm the validity, a specific number of experts will be appointed to evaluate the items in the instrument developed. The panel may include lay experts who are the potential research subjects. The number of experts to be appointed is arbitrary; at least five people are generally recommended to avoid agreement by chance. Should the number of experts increase, the probability of chance agreement decreases.

The researchers may conduct a "Delphi" method with panel of experts by arranging series of iterative questionnaires or meetings.[14,15] The consensus among the experts on the items in the instrument can be obtained after intensive discussion in series of meetings or it can be based on the anonymous responses to the iterative questionnaires. The process of multiple iterations collecting both qualitative and quantitative data helps reduce the range of responses and to reach consensus based on criteria chosen a priori by the researcher.

The expert panel can provide their quantitative and qualitative viewpoints on the relevancy or representativeness, clarity and comprehensiveness of the items to measure the specified construct. The content experts may also recommend about language and scores for the items in the instrument.

Step 3: Analysis of Content Validity—Assessing Quality of the Items in the Instrument

To confirm the content validity, several statistics have been proposed and used in literature. The most common ones are based on interrater agreement: content validity ratio (CVR) and content validity index (CVI).[7,10,11,16,17]

In evaluating CVR. the experts are requested to specify whether an item is "important" or "necessary" or "essential" for the concept desired to measure or not. The experts may be asked to score each item from 1 to 3 with the degree as shown in Table 2. The formula for $CVR = (N_e – N_t/2) / (N_t/2)$, in which the N_e is the number of experts indicating "essential" and N_t is total number of expert panel. CVR is easy to compute, but not so easy to interpret; its values can range from –1.0 to +1.0,

with CVR=0 when half the experts judge an item to be relevant.[16] The decision to eliminate or keep the item is usually based on the acceptable level of significance proposed by Lawshe.[17] As shown in Table 3, with 5 experts in the panel and 6 items in the measurement tool, the numbers of N_e vary among all items. Only item#1 passes the minimum value required under Lawshe's suggestion (i.e., using 5 experts requires CVR=0.99). The not-passed items should be eliminated or may require major revision.

Table 2. Proposed scoring for each item by expert panel

Score	Relevancy	Clarity	Essential
1	Not relevant	Not clear	Not necessary
2	Must be revised	Must be revised	Useful, but not essential
3	Relevant with minor revision	Clear with minor revision	Essential
4	Very relevant	Very clear	

Table 3. Content validity ratio (CVR) based on number of experts evaluated the item essential

Item	N_e-rate "Essential"	N_t-Total	CVR	Decision
1	5	5	1	Keep
2	4	5	0.6	Eliminate
3	3	5	0.2	Eliminate
4	2	5	-0.2	Eliminate
5	1	5	-0.6	Eliminate
6	0	5	-1	Eliminate

Note: Content validity ratio (CVR) = (N_e-N_t/2) / (N_t/2), N_e: the number of experts indicating "essential", N_t: total number of expert panel
Decision on CVR based on Lawshe's Table for minimum values of CVR
Number of panelists and minimum acceptable CVR value: 5,6,7=0.99; 8=0.75; 9=0.78; 10=0.62

CVI is another commonly used in assessing content validity. It is item-level information that can also be used to make decision whether to keep, revise or eliminate the items. In evaluating CVI, the experts are asked to rate instrument items in terms of relevancy and clarity in accordance with the concept the researchers want to measure. The rating scores may range between 1 to 4 as shown in Table 2.

The simplest form of item-level content validity index (I-CVI) is based on the criteria that the researchers simply set to make decision whether to keep, revise or eliminate the items. In a typical approach the researchers would appoint odd number of members for an expert panel. The researchers then set the criteria such that, if 2 of 3, 4 of 5, or 7 of 9 experts agreed on the relevancy of an item, they will keep that item. Another way to calculate I-CVI is based on the formula: I-CVI = N_{re} /N_t in which N_{re} is the number of experts rating at level 3 or 4 to the relevancy and N_t is the total number of experts in the panel. Thus, I-CVI reflects the proportion of agreement ranging between 0 and 1 as shown in Table 4.

The CVI of all items can be summarized as the scale-level content validity index (S-CVI). It can be calculated as an average of the I-CVIs for all items on the scale, so-called scale-level content validity index, averaging calculation method (S-CVI/Ave).

The strict agreement rate can be calculated based on absolute agreement on relevancy among experts, so-called scale-level content validity index, universal agreement calculation method (S-CVI/UA) as shown in Table 4.

Table 4. Item content validity index based on number of items considered relevant by 5 panelists

Item	Relevant (rating 3/4)	Not relevant (rating 1/2)	I-CVI	Decision
1	5	0	1	Excellent
2	4	1	0.8	Appropriate
3	3	2	0.6	Eliminate
4	2	3	0.4	Eliminate
5	1	4	0.2	Eliminate
6	0	5	0	Eliminate

Note: *Scale-level content validity index, averaging calculation method (S-CVI/Ave) = 3/6 = 0.50*
Scale-level content validity index, universal agreement calculation method (S-CVI/UA) = 1/6 = 0.17
Decision on I-CVI: >78% "Appropriate"; 70–79% "Need revision"; <70% "Eliminate"

Step 4: Pre-testing the Instrument—Ensuring the Questions and Answers are Comprehensible.

As recommended in literature, the draft of the instrument should be administered to 5–15 people representing targeted research participants in 2–3 rounds.[12] The responses can be in the format of verbalizing the mental process of what they understand while providing responses to the items in the instrument. This step may be repeated with revised version of the instrument should the items are still unclear or misunderstood by the respondents.

"Internal Consistency"—Is Your Research Instrument Reliable?

Quality of research instrument should be assessed not only for its validity but also its reliability. One of the most common and simplest statistics for reliability of data collected via questionnaire/interview forms is Cronbach's Alpha. Cronbach's alpha reflects internal consistency of a set of scores/scales of the items. It refers to the extent to which the instrument is a consistent measure of a concept.[4,8] The researchers should calculate reliability of the research instrument before they actually use that tool. However, researchers can also calculate it after they get the data for their research project to confirm the quality of their tool.

In order to have the reliable and reproducible evidence showing the consistency or stability of an instrument, the researchers must try out the instrument with a sufficient sample size. It is typically recommended to test the instrument with 30 subjects. However, for a single coefficient alpha test, assuming the null hypothesis of Cronbach's alpha coefficient=0, the sample size may be less than 30 to achieve a minimum desired effect size of 0.7 but if the null hypothesis set the coefficient larger than zero, a larger sample size is needed.[18]

Cronbach's alpha is computed by comparing the variances for all individual item scores with the variance of the total score: The formula is $\alpha = (k/(k-1))(1-\sum\sigma_{yi}^2/\sigma_x^2)$ in which k refers to the number of items, σ_{yi}^2 is the variance of item i, and σ_x^2 is the variance of the observed total scores (Table 5). Another way to calculate Cronbach's alpha is based on correlations among the items. The formula based on correlations for standardized $\alpha = k\, r_{avg} / (1 + ((k-1)\, r_{avg}))$ in which k refers to the number of items and r_{avg} is the average of all correlations among all pairs of items (Table 6).[19,20]

When the item is measured as binary (yes-no) rather than scores/scales (e.g., Likert's scale or others), Cronbach's alpha formula will be adjusted to the so-called Kuder-Richardson 20 formula. The use and interpretation of the Kuder-Richardson 20 formula is similar to the Cronbach's alpha.

Table 5. Cronbach's alpha based on item variance and total variance

Item	1	2	3	4	5	6	Total
Subject	y	y	y	y	y	y	x
1	y	y	y	y	y	y	x
2	y	y	y	y	y	y	x
3	y	y	y	y	y	y	x
⋮	y	y	y	y	y	y	x
n	y	y	y	y	y	y	x
	σ_{y1}^2	σ_{y2}^2	σ_{y3}^2	σ_{y4}^2	σ_{y5}^2	σ_{y6}^2	σ_x^2

Table 6. Cronbach's alpha based on interitem correlations

Item	1	2	3	4	5	6
1	1	r_{12}	r_{13}	r_{14}	r_{15}	r_{16}
2		1	r_{23}	r_{24}	r_{25}	r_{26}
3			1	r_{34}	r_{35}	r_{36}
4				1	r_{45}	r_{46}
5					1	r_{56}
6						1

Note: r_{avg} = average of r's

Coefficient of reliability ranges from 0 to 1. As a rule of thumb, the meaningful level of reliability is typically set as an acceptable threshold; for Cronbach's alpha reliability it is usually set at the minimum value of 0.7 or preferable 0.8.[19]

It is important to note that the value of alpha is dependent to the number of items; with high number of items, the alpha coefficient could be somewhat high even when the average interitem correlation is low. For example, the alpha coefficient is 0.71 when the average

interitem correlation of 10 items is 0.2.[20] It is thus recommended that a minimum alpha coefficient should be set at higher level when making important decisions from the use of a particular instrument; some suggest to use reliability at the level of 0.9 or above.[8,21] It should also be noted that Cronbach's alpha is not a measure of unidimensionality. The instrument may have high alpha even when there are multiple underlying dimensions or constructs. Test of constructs is a part of "construct validity" which can be analyzed by other kind of statistics, i.e., factor analysis.

Conclusion

So, you now know how to confirm the quality of your research instrument regarding the content validity and internal consistency. But…are you sure that your instrument has captured all essential theoretical constructs, or it will be reproducible when the entire research process is conducted again? That will need further steps.

Suggested Citation

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References

1. Oosterveld P, Vorst HCM, Smits N. Methods for questionnaire design: a taxonomy linking procedures to test goals. Qual Life Res. 2019 Sep;28(9):2501–12.
2. National Cancer Institute. NCI's dictionary of cancer terms: laboratory study [Internet]. Bethesda (MA): National Institutes of Health, U.S. Department of Health and Human Services; [cited 2023 Feb 15]. <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/laboratory-test>
3. Middleton F. Reliability vs. validity in research: difference, types and examples. Amsterdam: Scribbr; 2019 Jul 3 [updated 2023 Jan 30, cited cited 2023 Feb 15]. <https://www.scribbr.com/methodology/reliability-vs-validity>
4. Tang W, Cui Y, Babenko O. Internal consistency: do we really know what it is and how to assess it? Journal of Psychology and Behavioral Science. 2014 Jun;2(2):205–20.
5. Frost J. Content validity: definition, examples & measuring [Internet]. [place unknown]: Jim Frost; c2023 [cited 2023 Feb 15]. <https://statisticsbyjim.com/basics/content-validity/>
6. Shuttleworth M. Internal consistency reliability [Internet]. [place unknown]: Explorable.com; 2009 Apr 26 [cited 2023 Feb 15]. <https://explorable.com/internal-consistency-reliability>
7. Zamanzadeh V, Ghahramanian A, Rassouli M, Abbaszadeh A, Alavi-Majd H, Nikanfar AR. Design and implementation content validity study: development of an instrument for measuring patient-centered communication. J Caring Sci. 2015 Jun 1;4(2):165–178. doi:10.15171/jcs.2015.017.
8. Goforth C. Using and interpreting Cronbach's alpha [Internet]. Charlottesville (VA): Statistical Consulting Associate, University of Virginia Library; 2015 Nov 16 [cited 2023 Feb 15]. <https://data.library.virginia.edu/using-and-interpreting-cronbachs-alpha/>
9. Rubio DM, Berg-Weger M, Tebb SS, Lee ES, Rauch S. Objectifying content validity: Conducting a content validity study in social work research. Social Work Research. 2003 June:27(2);94–104. doi:10.1093/swr/27.2.94.
10. Zeraati M, Alavi NM. Designing and validity evaluation of quality of nursing care scale in intensive care units. J Nurs Meas. 2014;22(3): 461–71. doi:10.1891/1061-3749.22.3.461.
11. Yusoff MSB. ABC of content validation and content validity index calculation. Education in Medicine Journal. 2019;11(2):49–54. <https://doi.org/10.21315/eimj2019.11.2.6>
12. Boateng GO, Neilands TB, Frongillo EA, Melgar-Quinonez HR, Young SL. Best practices for developing and validating scales for health, social, and behavioral research: a primer. Front. Public Health. 2018 Jun 11; 6:149. doi:10.3389/fpubh.2018.00149.
13. Division of Mental Health and Prevention of Substance Abuse, World Health Organization. Programme on mental health: WHOQOL user manual [Internet]. Geneva: World Health Organization; 1998 [cited 2023 Feb 15]. 106 p. <https://apps.who.int/iris/handle/10665/77932>
14. Koller I, Levenson MR, Gluck J. What do you think you are measuring? a mixed-methods procedure for assessing the content validity of test items and theory-based scaling. Front. Psychol. 2017 Feb 21; 8:126. doi:10.3389/fpsyg.2017.00126.

15. Barrett D, Heale R. What are Delphi studies? Evidence-Based Nursing. 2020;23(3):68–9. doi:10.1136/ebnurs-2020-103303.

16. Polit DF, Beck CT, Owen SV. Is the CVI an acceptable indicator of content validity? appraisal and recommendations. Res Nurs Health. 2007 Aug;30(4):459–67. doi:10.1002/nur.20199.

17. Lawshe CH. A quantitative approach to content validity. Personnel Psychology. 1975; 28(4):563–75. doi:10.1111/j.1744-6570. 1975.tb 01393.x.

18. Bujang MA, Omar ED, Baharum NA. A review on sample size determination for Cronbach's alpha test: a simple guide for researchers. Malays J Med Sci. 2018;25(6):85–99. doi:10.21315/mjms2018.25.6.9.

19. Nunnally JC. Psychometric theory. 2nd ed. New York: McGraw-Hill; 1967.

20. Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika. 1951;16(3):297–334.

21. Nunnally JC, Bernstein IH. Psychometric theory. 3rd ed. New York: McGraw-Hill; 1994.

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