Did symptomatic index cases propagate COVID-19 more effective than the asymptomatic ones?: Analysis of Phuket contact tracing data in the first half of 2020

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Abstract

Unlike SARs and MERS, COVID-19 has its stealth mode. This present study aims to compare secondary attack rate among high-risk contacts exposed to symptomatic index cases to among those exposed to asymptomatic ones. The chi-square statistic and logistic regression analysis are used to compare infection probabilities of HRCs who have been exposed to symptomatic and asymptomatic cases. Results indicate no statistical difference in infection probability between HRCs exposed to asymptomatic cases and HRCs exposed to symptomatic cases. This present study findings also revealed the significant impact of close contact who share the same household. The contact who lives in the same household of the index case has eight times the odds of the non-household of COVID-19 index case during the April 2020's wave and five times the odds during April 2021's wave. We further recommend adding consistent active case finding as a prerequisite step to eliminate both symptomatic and asymptomatic COVID-19 case from the household.

Keywords: Asymptomatic transmission, COVID-19, High-risk contact (HRC), Household, Disease propagation

Introduction

The multiple waves of the COVID-19 pandemic in many nations empirically highlight its highly contagious capability. Recent studies by Buitrago-Garcia *et al.* (2020) have revealed that 20% of the 6,166 COVID-19 cases showed no symptoms throughout the infectious period. The World Health Organization defines symptomatic cases as infected people who have developed symptoms, while asymptomatic cases refer to people who are infected but never develop any symptoms (The World Health Organization [WHO], 2020a).

Following the early stages of the outbreak in China, in January 2020, Thailand was the second nation in the world to report COVID-19 infections. First cases in Phuket were logged in late January 2020, at which time the disease was elsewhere only found in Wuhan (WHO, 2020a). Following the initially documented cases in January 2020, the number of COVID-19 infections in Phuket sharply rose in late March and mid-April 2020. By the end of the first week of May 2020, the total number of COVID-19 cases stabilized at 227, which remained the total recorded number of infections until 2021. The infection rate in Phuket rose again at the beginning of April 2021 before the vaccination period; the total number of index cases had reached 329 at the end of April.

From the total of 214 index cases during the April 2020 wave, we found that 21% of the index cases were categorized as asymptomatic cases, and 35% index cases did not show any signs of the disease during the April 2021's wave. Although infected people have not developed symptoms, WHO confirmed infected people could transmit the SARS-CoV-2 virus both when they have symptoms and do not have any symptoms (The World Health Organization [WHO], 2020b) . Multiple findings also confirmed the transmissibility of COVID-19 from asymptomatic cases (Bai, *et al.*, 2020; Sayampanathan, *et al.*, 2020). A recent study that used systematic review found the global percentage of asymptomatic SARS-CoV-2 infections was

40.5 percent among the confirmed diagnosis, and the result suggests that asymptomatic individuals might be an essential driver of transmission in communities (Ma, *et al.*, 2021). Similarly, He *et al.* (2020) and Choi, Kim, Kang, Kim, and Cho (2020) found that SARS-CoV-2 could be transmitted before any respiratory symptoms develop. While Song Song, Yun, Noh, Cheong, and Kim, (2020), Arons *et al.* (2020), and Bai *et al.* (2020) found evidence of transmission from both presymptomatic and asymptomatic cases. These previous studies suggest that asymptomatic carriers cause a sizeable portion of COVID-19 transmissions. It could be hypothesized that asymptomatic cases can cause a relatively high threat to public health, as they tend not to self-isolate but remain circulating 'in' the community. However, Byambasuren *et al.* (2020) found asymptomatic individuals 42% less likely to transmit the virus than symptomatic cases. Sayampanathan *et al.* (2020) and Oran and Topol (2020) also found that an index case with asymptomatic COVID-19 is contagious but might be less so than the symptomatic case one. Gao, *et al.* (2020) conclude that SARS-CoV-2 patients with asymptomatic can transmit the virus, but the infectivity of some asymptomatic patient carriers might be weak.

A thorough understanding of SARS-CoV-2 transmission mechanisms would help public health policymakers manage disease transmission risks and economic policymakers to restore normal economic circumstances. The review of previous literature encouraged us to compare the differences between infection probabilities in two clusters of high-risk contacts (HRCs), which HRCs mean people who came in contact with the confirmed COVID-19 cases for longer than five minutes without wearing a mask. The first one consists of HRCs who contact asymptomatic cases, and another group refers to HRCs who had been exposed to the symptomatic index case.

Data and Methodology

This paper uses inferential statistic techniques to compare the infection probabilities of HRCs. They were exposed to the asymptomatic index cases with a group of HRCs exposed to the symptomatic individuals. The data used this study was a part of the investigation flow-chart which was undertaken by the Phuket Provincial Public Health office. After the person is confirmed by the Polymerase Chain Reaction (PCR) test as a COVID-19 case, an immediate in-depth telephone interview with the patient is conducted. This is done to obtain an extensive list of people with whom the patient might have been in physical contact during the past two weeks and for periods longer than five minutes without wearing a facial mask. With that information, a team from Phuket's Department of Disease Control classified the identified contacts as either high-risk contact (HRC) or low-risk contact (LRC) and further documented all contacts' demographic information and type of relationship with the index case(s). It should be noted that only a few contacts in Phuket were identified as low-risk contacts (LRCs) so far, and those included convenience store cashiers, food vendors, and people who interacted with index cases for a short period. HRCs' deidentified information is collected in an enscrpted spreadsheet, with slight corrections for spelling and date anomalies.

This study divided HRCs observations into two periods: the HRCs who contacted the COVID-19 patient in April of the 2020 wave; another is the group of the HRCs exposed to the COVID-19 cases in April of 2021. After that, the data for both periods were conducted by step. Firstly, the Chi-Square statistic which is commonly used for testing relationships between categorical variables (Wilson & Hilferty, 1931) was conducted to verify whether there is a statistically significant difference between the infection variable and the COVID-19 case's symptoms. Then, the infection probability of each HRC was simulated based on the proposed equation 1 including the case's symptom variable to explore the question of this paper.

Since this study's dependent variable is dichotomous, the two choices for this study were logit and probit models. Hahn and Soyer (2005) pointed out that the probit equation is preferable if the testing model does not contain independent variables with extreme values. As this study focuses on finding the marginal effect from each risk factor of transmission, both logit and probit models would yield relatively similar marginal effects (Breen, Karlson, & Holm 2018; Cornelißen & Sonderhof, 2009). However, as the study's exogenous variables are dummy and numerical, the logit model, which gives results interpretable by public health readers who are policymakers, was selected for the analysis to find the coefficient and odd ratio of each variable. The following equation was employed as the baseline regression.

$$Detected_i=\beta_0+\beta_1 Indexcase_{xi}\text{'}sSymptom+\beta_2 Household_i+\beta_3 GenderDifferential_i+\beta_4 Indexcase_{xi}\text{'}sAge+\beta_5 Contact_{xi}\text{'}s\ Age(0\text{-}4)+\beta_6 Contact_{xi}\text{'}sAge(5\text{-}17)+\beta_7 Contact_{xi}\text{'}sAge(18\text{-}29)+\beta_8 Contact_{xi}\text{'}sAge(30\text{-}39)+\beta_9 Contact_{xi}\text{'}sAge(40\text{-}49)+\beta_9 Contact_{xi}\text{'}sAge(50\text{-}64)+\beta_9 Contact_{xi}\text{'}sAge(65\ and\ above) \quad \textbf{(}\textbf{\textit{Equation}}\textbf{ 1)}$$

The endogenous variable in this model is whether the HRC i was detected with COVID-19 (1 if infected, 0 non-infected)[1]. The subscript xi represents case x in which contact i was exposed to. Variables included in the model were selected based on the analysis of the existing COVID-19 related literature. The following literature review discusses the COVID-19 transmission factors included in the statistical analysis.

Current evidence suggests that the COVID-19 virus spreads between people directly and indirectly (through contaminated objects or surfaces), particularly close contact by living within the same household with infected people. Chen *et al.* (2020) and Cauchemez *et al.* (2009), as well as Hui, Azhar, Kim, and Memish (2018) found that the COVID-19 and the respiratory virus spreads easier among people living within the same household. Westchester in the US had clear evidence of family cluster transmissions, while secondary household transmissions of the virus occurred among married couples in California and Illinois (Edwards,

[1] If contact's PCR test results were reported as positive either during, or before completion of the 14 days of quarantine, they would be regarded as 1.

2020). The previous literature also found some differences in the number of infections according to gender. A larger portion of COVID-19 reported cases in Switzerland, Spain, and Italy were female, while in Iran, male.

Another variable examined in this study is the infected cases' and their HRCs' age. This is because Bi *et al.* (2020) s' finding that individuals' infection risks appear statistically similar across various age groups. However, an investigation by Li *et al.* (2020) and Khan (2020) found that the secondary infection rate in children occurred in lower numbers than in adults. However, the recent report of Centers for Disease Control and Prevention (2022b) shows no difference risk of infection between nine age groups. Thus, the age still be ambiguous variable for transmission risk and need more study.

Results

This study applied the statistical analysis of high-risk contact of COVID-19 index cases in Phuket. The data cover two primary waves of the outbreak in Phuket during April 2020 and April 2021; descriptive information of indexed cases and HRCs are illustrated in Table 1. In April of the year 2020, the 214 cases were recorded between January and April 2020 which account for 93% of all COVID-19 cases in Phuket as of December 2020, 169 patients show some symptoms while another 45 cases were asymptomatic patients, and found 1,088 HRCs from the 214 index cases (Phuket Provincial Public Health Office, 2020) For the year 2021, Phuket Provincial Public Health Office recorded 119 index cases during April 112 of them were verified to be symptomatic index cases and 61 index cases did not show any symptoms and all 119 index cases had close contact with 1,368 HRCs (Phuket Provincial Public Health Office, 2021).

[Insert Table 1]

172 of 1,088 HRCs were later diagnosed as COVID-19 cases of the 2020 dataset, and 119 of 1,386 HRCs were later diagnosed as the COVID-19 case during 2021's wave; this shows the higher infection rate during the initial wave (15.81%) than in the second major wave in April 2021 (8.59%).

The key variable in the testing equation is whether the index case that HRCs had exposed is asymptomatic or systematic. It would be myopia interpretation to categorize the HRCs exposed to both asymptomatic and symptomatic index cases. This study excluded HRCs who had exposure to more than one index case from the study (detailed information is described in Table 2), in order to reduce the repeated measure problems

[Insert Table2]

The number of selected HRCs in April 2020 is 614; 584 got exposed to the 102 index symptomatic cases, while 30 HRCs got exposed to the five index cases categorized as asymptomatic. While 668 HRCs from in April of 2021, 493 of the selected HRCs had contacted 67 symptomatic index cases, 175 HRCs got exposed to the 27 asymptomatic index cases. The infection rate of HRCs exposed to asymptomatic cases (16.67% in 2020 and 9.14% in 2021) is higher than HRCs exposed to symptomatic cases in both waves (6.51% and 9.14% in 2020 and 2021 respectively) in both periods.

However, the result of Chi-Square, which tests the difference between the infection variable and the COVID-19 case's symptoms, was reported as significant at a 95% level of confidence in only the 2020 period. However, the result of Chi-Square only confirmed the statistical differences for only the 2020 dataset. This implies we found a significant difference in infection rates between the HRCs exposed to asymptomatic and symptomatic cases only in 2020. To fully investigate the exposure risk between asymptomatic and symptomatic index cases, , the logistic regression was conducted to find the coefficient and odd ratio of each variable based

on equation 1. The explanation and descriptive result of the variables proposed in equation by time period are reported in Table 3.

[Insert Table 3]

The interpretation of odd ratio (OR) of the variables proposed in equation 1 are reported in Table 4 and interpreted as follow.

[Insert Table 4]

Table 4 illastrate COVID-19 exposure risk of HRCs through their exposure of either symptomatic or asymptomatic index cases and other control variables for both periods with the simulated probability of HRC by the logistic regression. It reveals that the difference in infection probability between HRCs exposed to asymptomatic cases and HRCs exposed to symptomatic cases was no longer statistically significant at 95% CI. This result represents that the potential transmission risk of asymptomatic infections is not different from that of an index case with symptoms. The output of this study was similar to the studies reported earlier in 2020 and 2021 (Bai, et al., 2020; Ma, et al., 2021). The study of 3,790 HRCs in Singapore by Sayampanathan *et al.* (2020) recently revealed no relationship between the infection rate of HRCs and the serology status of the index case, it could be that close contacts tend to regular get in touch with the index case and virus spreading happens before a person who was infectious turns to seropositive.

However, the analysis from both 2020 and 2021 datasets showed that variables representing household infection attacks were reported at a 99% confidence level. It was found that the odd ratio of contacts who share the same household was as high as 7.93 (95% CI: 3.98-15.80), and 5.05 (95% CI: 2.83 - 9.02) in the year 2020 and 2021. This implies the HRCs who live in the same household of the index case have eight times the odds of the non-household group of COVID-19 index case in 2020 and approximately five times the odds in the period of 2021.

Similar results were found in the recent studies by Chen *et al.* (2020) and Edwards (2020), the virus spread more easily amongst people living in the same household.

No relationship was found between HRCs' infection probability and other control variables, age, and gender differential; these indicate the difference in age and gender among HRCs could not statistically result in differences in infection probability of HRCs.

Discussion and Policy implication

Phuket was among the first area in the world with the reported COVID 19 cases, the first imported case was detected as early as January 2020. However, the island's major outbreak occurred through local transmissions in April 2020; daily new cases gradually declined toward zero new cases at the end of April 2020. A year apart, the second major outbreak on the island started again in April 2021.

The descriptive analysis indicated that the infection rate among HRCs exposed to symptomatic index cases is higher than that of HRCs with exposure to asymptomatic index cases for both waves. However, the Chi-square test only confirms the statistical differences between the odds of these two groups of HRCs in 2020. In the subsequent regression analysis and 95% CI, an exposure of HRCs to either asymptomatic or symptomatic cases could not result in a difference in HRCs' infection probability. This study remarked the potential transmission risk of asymptomatic infections is not more than the transmission risk of an index case with symptoms. Thus, HRCs with recorded exposure to symptomatic or asymptomatic cases should be treated with equivalent measures, including isolation containment and contact tracing procedures (Ma, *et al.*, 2021).

This study's finding of household secondary attacks in both waves should once again draw attention to the intensity of household COVID-19 attacks, as Li *et al.* (2020) and Phucharoen,

Sangkaew, and Stosic (2020) also found. Chen *et al.* (2020), Cauchemez *et al.* (2009), and Hui *et al.* (2018) also found a higher risk of transmission within the households. This finding implies the transmission capabilities of COVID-19 between contacts who work with or live in the same accommodation with an index case. A plausible explanation for continuous transmissions within Thai households could be derived from the recent behavior study (Faculty of Economics, Chulalongkorn University, 2020), which found that 70-80% of Thai households still share meals for Breakfast, Lunch, and Dinner, even in the midst of the COVID-19 pandemic. These combined findings therefore recommend further studies of ethnic groups' meal preferences within households, in order to better equip public health authorities worldwide on the ways of further reducing the transmission probabilities within households.

With the application of this finding to vulnerable infection groups, elderly members and household members with chronic health conditions considered SARS-CoV-2 valunerable group (Centers for Disease Control and Prevention, 2022a) should be separated from sharing the same roof with index case who either has or does not has the symptoms.

The present statistical analysis of this paper does not particularly highlight the camouflage operation of COVID-19, as it can spread during presymptomatic or asymptomatic index cases (Bai *et al.*, 2020; Arons *et al.*, 2020; Song *et al.*, 2020). The result of this study further emphasizes the potential for infections within households. Early detection, either through self-screening or state provided screening and immediate isolation of indexed cases from the elderly and household members with chronic health conditions could reduce loss or public health burden to protect a vulnerable group of household members.

COVID-19 is still considered a concurrent pandemic, and many researchers across the globe are continuously investigating the newly emerged SARS-CoV-2 disease. One of the limitations in this analysis is the construction of the testing models, as they were based on the disease's

current understanding. Therefore, the exogenous variables list is not complete to include all factors that could potentially affect HRCs' infection probability. In addition, the surveillance data could only reflect whether the contact lived in the same household with the index case as a dummy variable. Still, the data in this analysis does not contain detailed information on household sizes, house sharing facilities, or physical dimensions of dwellings. Finally, the present study is based on contact tracing data in Phuket, which has specific geographical characteristics and during two major waves. The data do not represent the Delta and Omicron waves, which imposed even more daily infections on the island. Last, Phuket is an island where authorities can control the population's mobility at an absolute scale during the first and second waves in 2020 and 2021 respectively. Therefore it would be interesting to test the applied statistical model on other areas' contact tracing data on either at regional or national scale and verify the results of this study.

Ethics approval and consent

For this study, the Institutional Review Board or any formal approval from the ethical committee is not required as the study uses pre-existing and deidentified data. Data is anonymized and irreversibly deidentified to protect index cases and all contacts. It should be noted that the identifying details of observations also remained completely anonymous. No trials were conducted on either humans or animals for this study.

Role of Funding

No funding was received in study design, data collection, data analysis, data interpretation, writing of the article, or the decision to submit for publication. All authors had full access to all anonymized data in the study and were responsible for submitting the article for publication.

Declaration of interest

We declare no competing interests.

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Table

Table 1 Descriptive statistics of two types of confirmed cases and high-risk contacts (HRCs)

Period	Confirmed cases		HRCs' Infection			Percentage of Infection
			Non detected	Detected	Total	
April 2020	Symptomatic	169	916	172	1088	15.81%
	Asymptomatic	45				
	Total cases	**214**				
April 2021	Symptomatic	112	1267	119	1386	8.59%
	Asymptomatic	61				
	Total cases	**173**				

Table 2 Descriptive statistics of selected confirmed cases and high-risk Contacts (HRCs) and Chi-square tests of HRCs' Infection between symptomatic and asymptomatic cases

Period	Confirmed cases		HRCs' Infection			Percentage of Infected	Chi-Square Tests	
			Non detected	Detected	Total		Pearson Chi-Square Sig. (2-tailed)	Fisher's Exact Test Sig. (2-tailed)
April 2020	Symptomatic	102	546	38	**584**	6.51%	0.033**	0.050**
	Asymptomatic	5	25	5	**30**	16.67%		
	Total cases	**107**	**571**	**43**	**614**	**7.00%**		
April 2021	Symptomatic	**67**	453	40	**493**	8.11%	0.673	0.638
	Asymptomatic	**27**	159	16	**175**	9.14%		
	Total cases	**94**	**612**	**56**	**668**	**8.38%**		

Note: The figure reported with * are significant with 0.1 significance level, the figure reported with ** are significant with 0.05 significance level, figures reported with *** are significant at 0.01 significance level.

Table 3 The explanation and descriptive statistics of the variables proposed in equation by period.

Characteristics	Measurement		April 2020		April 2021	
			Infected HRC	**Non-infected HRC**	**Infected HRC**	**Non-infected HRC**
Detected	Whether HRC was a COVID-19 confirmed case		43	570	56	612
Index cases' Symptom	Whether index cases show any signs that the disease is present in their body.	Symptomatic (1)	38	546	40	453
		Asymptomatic (0)	5	25	16	159
Gender differential	Gender differential between an index case and HRC	yes (0)	26	342	25	308
		No (1)	17	229	31	304
Household	Whether HRC lived in the same household with the confirmed case during the past 14 days	Yes (1)	20	59	32	136
		No (0)	23	512	24	476
Index cases' age	Age of each index case (year)		44.8-year-old in average	38.7-year-old in average	37.2-year-old in average	39.1-year-old in average
HRC Age[†]	Age of high-risk contact (HRC) by group	0-4	1	15	0	0
		5-17	4	55	0	0
		18-29	13	164	25	198
		30-39	5	139	12	211
		40-49	10	99	12	125
		50-64	7	82	7	78
		65 and above	3	16	0	0

[†]Note: It should be noted for 1 of them were excluded from the analysis, due to the missing information about the required variables.

Table 4 Results of secondary attack rate among high risk analysis by logistic regression model

Variables	Odds Ratio for COVID-19 secondary attack in April 2020				Odds Ratio for COVID-19 secondary attack in April 2021			
	Beta	**P value**	**Odd Ratio (OR)**	**95% CI of OR**	**Beta**	**P value**	**Odd Ratio (OR)**	**95% CI of OR**
Intercept (Constant)	-20.46	1.00	<0.001	(-)	-3.19	<0.001	0.04	(-)
Index cases' Symptom	-1.07	0.06	0.34	(0.11 - 1.0)	-0.09	0.77	0.91	(0.47 - 1.71)
Household	2.07	<0.001	7.93	(3.98 - 15.80)	1.62	<0.001	5.05	(2.83 - 9.02)
Gender differential	-0.31	0.39	0.74	(0.37 - 1.49)	0.26	0.38	1.30	(0.73 - 2.30)
Index cases' age	0.02	0.08	1.02	(1.00 - 1.039)	-0.01	0.42	0.99	(0.98 - 1.01)
Contacts' age (0-4)	17.54	1.00	>999.99	(<0.001 - >999.999)	-	-	-	(-)
Contacts' age (5-17)	17.53	1.00	>999.99	(<0.001 - >999.999)	-	-	-	(-)
Contacts' age (18-29)	17.76	1.00	>999.99	(<0.001 - >999.999)	0.76	0.11	2.14	(0.85 - 5.40)
Contacts' age (30-39)	17.09	1.00	>999.99	(<0.001 - >999.999)	-0.13	0.80	0.88	(0.32 - 2.40)
Contacts' age (40-49)	18.08	1.00	>999.99	(<0.001 - >999.999)	0.55	0.30	1.72	(0.62 - 4.84)
Contacts' age (50-64)	17.71	1.00	>999.99	(<0.001 - >999.999)	-	-	-	(-)
Contacts' age (65 and above)	18.42	1.00	>999.99	(<0.001 - >999.999)	-	-	-	(-)
Number of observations			613[†]				668	
Observations with Dep=0			570				612	
Observations with Dep=1			43				56	
Pseudo R Square			0.179				0.123	

[†] It should be noted for 613 observations, 1 of them were excluded from the analysis, due to the missing information about the required variables.