Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Original Research

Correlations between control of COVID-19 transmission and influenza occurrences in Malaysia

K.H.D. Tang [a, *], B.L.F. Chin [b]

[a] Environmental Science Program, Division of Science and Technology, Beijing Normal University-Hong Kong Baptist University United International College, 2000 Jintong Road, Tangjiawan, Zhuhai, GD, 519087, China
[b] Department of Chemical Engineering, Faculty of Engineering and Science, Curtin University Malaysia, CDT 250, 98009, Miri, Sarawak, Malaysia

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ABSTRACT

Objectives: The transmission of COVID-19 has sent Malaysia into cycles of tightening and relaxation of movement control, which are still continuing currently in line with local fluctuations of new COVID-19 cases. During movement control, measures comprising physical distancing, hand cleaning or sanitizing, and sanitization of premises are consistently implemented while self-isolation and travel restrictions are adaptively enforced. This study aims to examine if the control of COVID-19 transmission has an effect on the national influenza occurrences as some measures for COVID-19 control are similar to those for influenza.

Study design: For this study, data of weekly new cases of influenza and COVID-19 were obtained from official platforms for non-parametric statistical analysis.

Methods: This study compared the influenza occurrences before and after the onset of COVID-19 using the Mann–Whitney U-test and explored Spearman's correlations between COVID-19 and influenza incidences after the onset of COVID-19.

Results: It shows that influenza incidences before and after the onset of COVID-19 were significantly different and that influenza cases have significantly reduced after the onset of COVID-19. The weekly cases of influenza and COVID-19 were significantly and negatively correlated.

Conclusions: This study underscores the co-benefits of COVID-19 control measures and alleviates the concern for the risk of COVID-19 and influenza co-infection.

Introduction

COVID-19 was first detected on 31 December 2019 in Wuhan, China and in less than a month, its arrival in Malaysia involving three Chinese citizens was reported on 25 January 2020.[1] Malaysia recorded a total of eight confirmed cases of COVID-19 on 30 January 2020, all involving Chinese citizens. On 4 February 2020, the first local infection was reported. Since 27 January 2020, a series of travel restrictions have been imposed by the Malaysian Government.[1] The Movement Control Order (MCO) was enforced on 16 March 2020 as the cases of COVID-19 mounted. Since then, Malaysia has gone through a few cycles of local tightening and relaxation in its combat against COVID-19 in line with local fluctuations of COVID-19 cases.[1] To date, the Conditional Movement Control Order (CMCO) as a less stringent variant of the MCO is still implemented in most regions of Malaysia with resurging cases of COVID-19.[2] The implementation of MCO has seen the compulsory adoption of precautionary measures such as self-isolation, physical distancing, mask-wearing, hand cleaning, and sanitization of premises in tandem with strict travel restrictions.[3] Many of the measures particularly physical distancing, hand cleaning, and sanitization of premises are still practiced in the continual combat against COVID-19, while self-isolation and travel restrictions are situationally tightened and relaxed, often seen in the cycles of closure and reopening of certain non-essential services as well as adaptive rules on social gathering and cross-district or cross-state travels within the country.[2,3]

Coincidentally, COVID-19 and influenza are caused by contagious viruses, which attack the respiratory system, and they are transmitted in similar ways through droplets, body contacts, and contacts with surfaces containing the viruses.[4,5] However, COVID-19 has an overall higher transmission rate than influenza and

* Corresponding author.
E-mail address: daniel.tangkh@yahoo.com (K.H.D. Tang).

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could result in more serious symptoms in certain individuals including chest pain and breathing difficulty, which often prompts the use of ventilators.[4] Influenza typically has an incubation period of 1–4 days whereas COVID-19 has a longer incubation period of 2–14 days.[4] A median incubation period of 5.1 days for COVID-19 has been reported.[6] Precautionary measures to control the transmission of COVID-19 and influenza are similar in certain aspects such as physical distancing, mask-wearing, and hand sanitizing.[7] Sanitization of premises is less prevalent in the control of influenza, probably because influenza is generally less severe than COVID-19 and the vaccines for influenza are more established. Influenza is caused by the influenza viruses and there are four types of influenza viruses, namely A, B, C, and D.[8] Influenza types A and B are responsible for seasonal epidemics while influenza type C infects children mainly, causing mild symptoms. Influenza type D is not known to infect or cause illness among humans.[8] In Malaysia, influenza types A and B are common. The A (H1N1) pdm09 virus that emerged in mid-2009 is still prevalent in Malaysia and has been reported to co-circulate with subtype A (H3) and type B viruses.[9]

With similarities in the transmission means of COVID-19 and influenza, certain precautionary measures against COVID-19 spread have also been employed for influenza even before the rise of COVID-19. In view of their common clinical manifestations, similar means of transmission prompting similar precautions, co-existence, and the possibility of co-infection, it is, therefore, of interest to examine if the combat against COVID-19 in Malaysia has an effect on the national influenza cases and whether it yields any co-benefits in controlling influenza. Influenza is known to exist all year round in tropical countries like Malaysia where its seasonal variation is less obvious. It burdens the healthcare system of the country to a certain extent.[10] As such, changes in the incidence of influenza due to the implementation of COVID-19 control measures would have implications on the national healthcare.

Currently, there is no regional study conducted to examine the effects of COVID-19 control on influenza cases. Such studies are few even on a global scale. Relevant studies mostly concern influenza and COVID-19 co-infection as well as threats due to the co-existence of influenza and COVID-19.[4,11,12] There are also studies related to influenza vaccination to reduce influenza infection and co-infection with COVID-19.[13,14] There is one study examining the potential decrease of influenza in the United States, Australia, Chile, and South Africa as the COVID-19 pandemic unfolded in 2020 but the study lacks statistical analyses.[7] In view of the concern for COVID-19 and influenza co-infection, a study on the incidence of influenza during the COVID-19 era would help to address the concern.

Methods

Data of daily new COVID-19 cases in Malaysia were sourced from the data platform maintained by the Centre for System Science and Engineering (CSSE) of John Hopkins University.[15] COVID-19 was detected in Malaysia on 25 January 2020 and Malaysia entered the first phase of movement control on 18 March 2020 with steadily increasing cases of COVID-19.[1] During movement control, the public were ordered to self-isolate and practice physical distancing and there was strong advice on the wearing of masks and hand sanitizing. Sanitization of premises was also vigorously conducted.[1] More than a year after the outbreak, while self-isolation has been lifted, physical distancing, the wearing of masks, the upkeep of personal hygiene, and disinfection are still frequently implemented and are claimed to be the new norms.[3] The data for COVID-19 cases from Week 6 of 2020 starting on 3 February 2020 till Week 14 of 2021 ending on 4 April 2021 were extracted from the database to demonstrate the progression of COVID-19 since the early stage of its onset in Malaysia (also see Fig. 1 for the timeline).

Data for the weekly number of influenza cases were obtained from the FluNet fed by the Global Influenza Surveillance and Response System (GISRS) maintained by the World Health Organization (WHO). Two sets of weekly influenza data were sourced.[16] One set of the data comprised the weekly number of influenza cases from Week 49 of 2018 commencing on 3 December 2018 to Week 5 of 2020 ending on 2 February 2020, while the other set of the data comprised the cases from Week 6 of 2020 to Week 14 of 2021 in parallel to the weekly COVID-19 cases (Fig. 1). The former represented the number of influenza cases before the implementation of COVID-19 precautionary measures while the latter represented the number of influenza cases during the development, implementation, and continual upkeep of COVID-19 precautionary practices in line with the unfolding of COVID-19 transmission in Malaysia and its progression to the current new norms in the COVID-19 era. The first COVID-19 cases were detected in Malaysia on Week 4 of 2020. With the increase of cases in the subsequent week, flight suspension, travel restriction, and precautionary measures were initiated. It is therefore deemed that Week 6 of 2020 is sufficiently representative of the commencement and development of COVID-19 precautions in Malaysia.[1] The influenza cases were classified based on the types and subtypes of influenza viruses detected. There were two types of influenza viruses detected, i.e. type A and type B. The subtypes of influenza A viruses reported in the period of interest were A (H1N1) pdm09 and A (H3) and other non-subtyped A viruses, whereas those of influenza B viruses were labeled as lineage not determined. This is

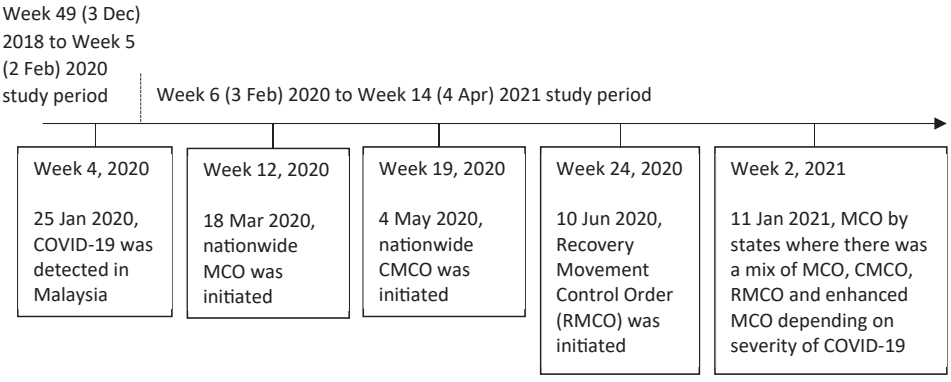

Fig. 1. Timeline of COVID-19 pandemic in Malaysia and the data periods analyzed. MCO, Movement Control Order; CMCO, Conditional Movement Control Order.

because, unlike influenza A viruses, the lineages of influenza B viruses were not differentiated during diagnostic tests.

Statistical analyses were conducted to determine the correlations between the data and whether the datasets before and after the onset of COVID-19 in Malaysia were significantly different. A normality test was conducted on the datasets to determine if parametric or non-parametric tests would be adopted for the analyses. The Shapiro–Wilk test of normality showed $P < 0.05$, indicating a lack of normal distribution of the data.[17] Therefore, non-parametric analyses were conducted where Spearman's correlation was employed for correlational analysis between the COVID-19 cases and cases of influenza after the onset of COVID-19 (Week 6 of 2020 to Week 14 of 2020) to identify if patterns of variations in weekly COVID-19 and influenza incidences during this period were linked, without any assumption made on the directions of variations. The correlational analysis did not aim to show the causal relations of any significant variation patterns of the data and it mainly served as a supplementary analysis in the identification and explanation of significant trends. More importantly, the Mann–Whitney U-test was employed to determine if the datasets before and after the onset of COVID-19 were significantly different.

Results

Table 1 shows the descriptive statistics of the weekly COVID-19 cases from Week 6 of 2020 to Week 14 of 2021 as well the cases of influenza by subtype within the same period and from Week 49 of 2018 to Week 5 of 2020. The weekly new cases of COVID-19 averaged at 821.9 over the 61 weeks tracked, during which all influenza cases were consistently lower than 1 in comparison to the 61 weeks prior to the onset of COVID-19. Skewness and kurtosis provide an indication of normality, with a skewness of 0 representing a symmetrical dataset and a kurtosis of 3 representing sizes of two tails mirroring normal distribution.[17] The extent of deviation from a skewness of 0 and a kurtosis of 3 implies the extent of deviation from the normal distribution. Table 1 shows varying levels of deviation from normality, which agree with the results of the Shapiro–Wilk test of normality revealing a lack of normal distribution, hence the appropriateness of non-parametric tests for this study.

Table 1
Descriptive Statistics of the Weekly New Cases of COVID-19 and Influenza.

Weekly New Cases	*n*	Mean ± SD	Skewness	Kurtosis
From Week 6 of 2020 to Week 14 of 2021				
COVID-19	61	821.90 ± 1135.26	1.52	1.64
A (H1N1) pdm09	61	0.77 ± 2.21	2.95	7.74
A (H3)	61	0.64 ± 1.80	2.88	7.51
A (not subtyped)	61	0.16 ± 0.76	5.44	31.26
B (lineage not determined)	61	0.25 ± 1.03	4.82	23.60
From Week 49 of 2018 to Week 5 of 2020				
A (H1N1) pdm09	61	7.41 ± 6.59	1.26	1.06
A (H3)	61	3.16 ± 2.60	0.62	−0.48
A (not subtyped)	61	2.23 ± 3.48	2.12	4.42
B (lineage not determined)	61	9.08 ± 7.33	1.13	1.14

Fig. 2 shows the weekly cases of COVID-19 from Week 6 of 2020 to Week 14 of 2021. The weekly new cases were consistently below 250 until Week 41 of 2020 (equivalent to Week 36 in Fig. 2) in which the new cases shot to 691.57. The weekly new cases increased progressively after that, peaking at 4451.14 in Week 5 of 2021 (equivalent to Week 52 in Fig. 2) and signaling a new wave of COVID-19 transmission. The spike of COVID-19 cases since Week 41 or October 2020 could be attributed to the relaxation of the CMCO, which was set to replace the MCO implemented between 18 March 2020 and 3 May 2020 (Fig. 1).[18] The CMCO came into force on 4 May 2020 and ended on 9 June, after which the RMCO took over. Implementation of the RMCO saw the lifting of a number of restrictions such as those on interstate travel, religious activities, meeting, and events as well as non-essential services such as wellness and entertainment centers.[18] The RMCO was extended until 31 March 2021 with the re-implementation of MCO and CMCO in certain states where the COVID-19 cases were high (Fig. 1).[18] In Week 5 of 2021 (Week 52 in Fig. 2), there was a mix of RMCO, MCO, and CMCO implemented throughout Malaysia with MCO effected in states with alarming new COVID-19 cases.[2,18] This resembles the suppression and relaxation model of COVID-19 control practiced in many other regions of the world.[19]

Fig. 3a shows a sharp drop of influenza cases as early as Week 11 of 2020 (equivalent to Week 6 in Fig. 3a) while cases of A (H1N1) pdm09 and A (H3) decreased to zero on Week 14 of 2020 (equivalent to Week 9 in Fig. 3a), almost two weeks after the commencement of MCO. The influenza cases have remained at zero most of the time since then until Week 14 of 2021. In contrast, the influenza cases during the pre-COVID-19 period from Week 49 of 2018 to Week 5 of 2020 fluctuated, and A (H1N1) pdm09 and B

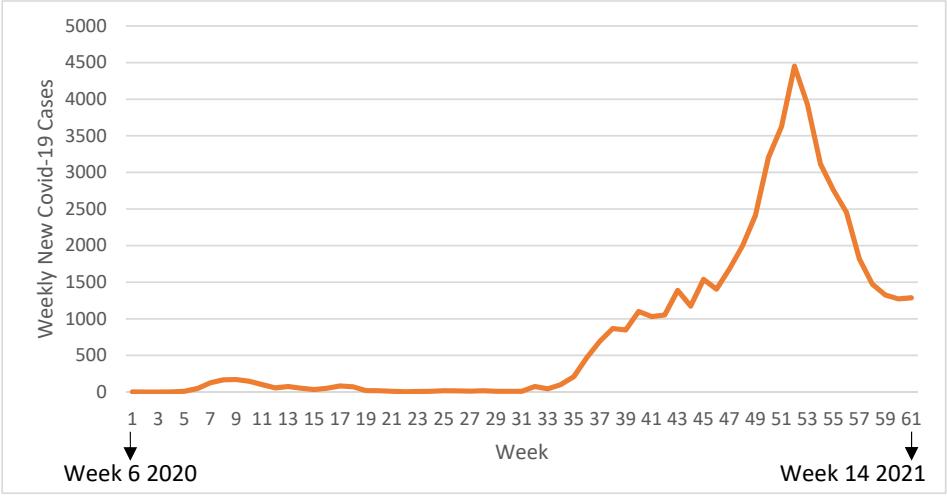

Fig. 2. Weekly new COVID-19 cases from Week 6 of 2020 to Week 14 of 2021 (note: Week 6 of 2020 is denoted as Week 1 in the graph).

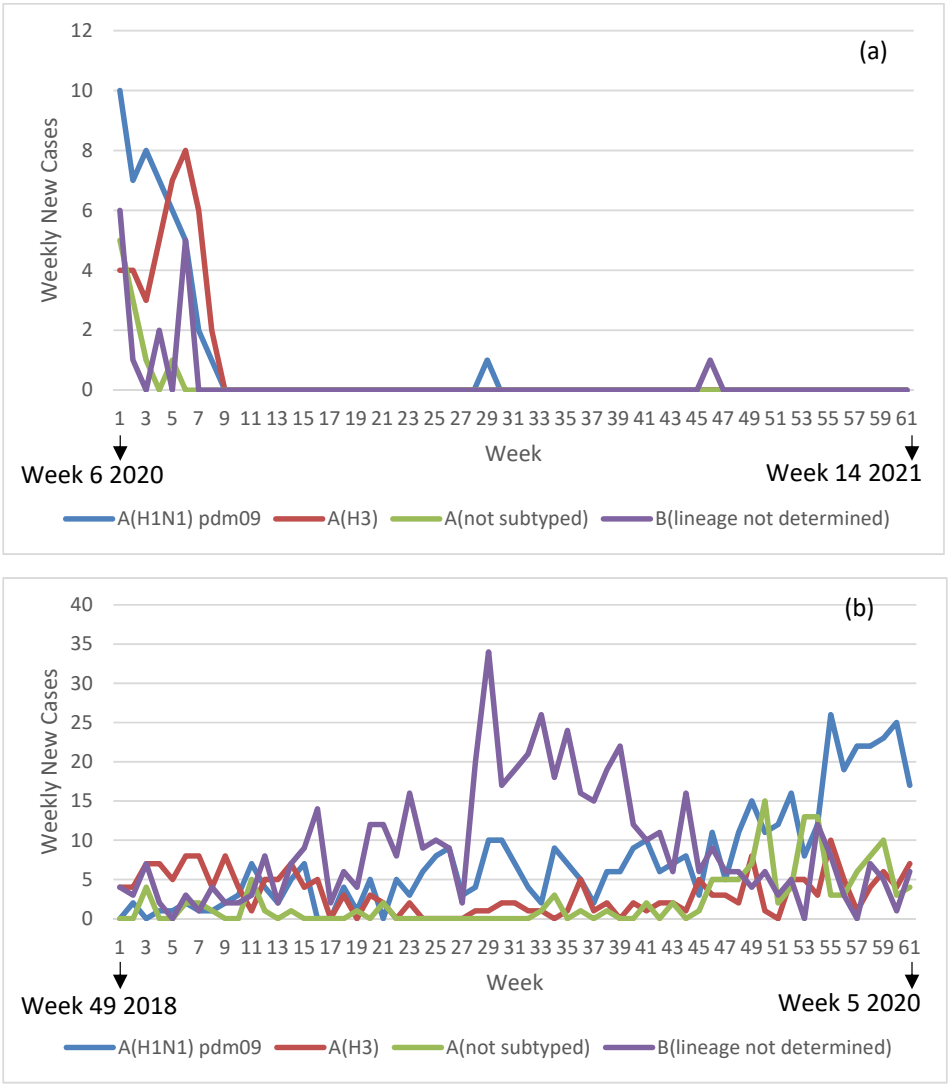

Fig. 3. Weekly new influenza cases from (a) Week 6 of 2020 to Week 14 of 2021 and (b) Week 49 of 2018 to Week 5 of 2020 (note: the beginning of the study period is denoted as Week 1).

seemed to be more prevalent. Influenza B cases peaked in Week 25 of 2019 (equivalent to Week 29 in Fig. 3b) and remained high in the next 10 weeks, whereas A (H1N1) pdm09 cases rose in Week 51 of 2019 (equivalent to Week 55 in Fig. 3b) and were high in the following 5 weeks.

The Mann–Whitney U-test was performed on the influenza datasets before and after the onset of COVID-19 to determine if the implementation of the COVID-19 control measures had any significant effects on the influenza cases. The Mann–Whitney U-test in Table 2 shows that the asymptotic significance, *p*, of all the paired datasets of influenza subtypes was <0.001, demonstrating significant differences (Table 2)

Spearman's correlation shows that weekly new COVID-19 cases have significant negative correlations with weekly new cases of A (H1N1) pdm09 ($r_s = -0.44$), A (H3) ($r_s = -0.39$), and A (not subtyped) ($r_s = -0.40$) at $P = 0.01$ (Table 3). At $P = 0.05$, the negative correlation between weekly new COVID-19 cases and weekly new influenza B cases is significant(Table 3)the negative correlations, albeit slight to moderate, are statistically significant, indicating that the influenza cases decreased with advancing COVID-19 and its transmission control. Significant positive correlations are observed among the influenza cases possibly due to the concerted decline in the cases of all the influenza subtypes reported. The positive

Table 2
Mann–Whitney U-test for Influenza Cases Before and After the Onset of COVID-19.

Pair of Influenza Cases[a]	Mann–Whitney U	Wilcoxon W	Z	Asymptotic Significance (two-tailed)
A1(H1N1) pdm09	371.50	2262.50	−8.05	<0.001
A (H3)	610.00	2501.00	−6.91	<0.001
A (not subtyped)	989.50	2880.50	−5.54	<0.001
B (lineage not determined)	146.50	2037.50	−9.32	<0.001

[a] Week 6 of 2020 to Week 14 of 2021 and Week 49 of 2019 to Week 5 of 2020.

Table 3
Spearman's Correlation between COVID-19 and Influenza Cases from Week 6 of 2020 to Week 14 of 2021.

	COVID-19	A (H1N1) pdm09	A (H3)	A (not subtyped)	B (lineage not determined)
COVID-19	1.00				
A (H1N1) pdm09	−0.44[a]	1.00			
A (H3)	−0.39[a]	0.94[a]	1.00		
A (not subtyped)	−0.40[a]	0.69[a]	0.67[a]	1.00	
B (lineage not determined)	−0.27[b]	0.59[a]	0.61[a]	0.42[a]	1.00

[a] Correlation is significant at the 0.01 level (two-tailed).
[b] Correlation is significant at the 0.05 level (two-tailed).

correlation was particularly strong between A (H1N1) pdm09 and A (H3) ($r_s = 0.94$).

Discussion

Since the onset of COVID-19, wearing of masks and upkeeping of hand hygiene have been practiced and these practices culminated when the MCO came into force.[1] During MCO, there were strict regulations on physical distancing, self-isolation, travel, and sanitization of premises.[1] Even after the transition to CMCO and RMCO, physical distancing, wearing of masks, upkeeping of hand hygiene, and sanitization have been widely practiced while self-isolation and travel restrictions are situational and have been imposed to different extents.[20] The practices of physical distancing, wearing of masks, and upkeeping of hand hygiene are collectively known as the new norms in the COVID-19 era, and their wide adoption might have contributed to the reduction in weekly new cases of all influenza subtypes reported, which is shown in Fig. 3a.[3]

Fluctuation in the influenza cases before the onset of COVID-19 (Fig. 3b) seemed to imply seasonal variations. Roussel et al. investigated the correlation between weekly variations of influenza cases and climatic factors in a temperate setting.[21] They found average temperature, absolute humidity, sunshine duration, and relative humidity to have significant impacts on the weekly variations but singling out the factors was difficult. In Malaysia located in the tropics, the seasonal variation of influenza cases is less obvious and influenza cases are reported throughout the year.[9] This aligns with Fig. 3b that there were influenza cases all year round. Despite the spikes in Fig. 3b, seasonal variation of the influenza cases cannot be concluded from this study and is outside the scope of this study.

While measures to combat COVID-19 have been implemented since its onset, the measures seem to be more effective in bringing down influenza cases compared to COVID-19, likely because of the higher reproductive number of COVID-19, which has resulted in its quicker transmission.[22] In addition, the longer incubation period of COVID-19 compared to influenza and the lack of symptoms in certain individuals also contribute to the difficulty in its detection at the early stage of infection.[4] Therefore, unlike influenza, resurgence of COVID-19 cases has occurred throughout the movement control period in Malaysia.

Malaysia was generally well-prepared for COVID-19 since the WHO declared it a global pandemic during which the Ministry of Health implemented a robust preparedness plan which involved ramping up screening and sampling at entry points as well as health clinics and hospitals.[23] Besides, the Malaysian Government also collaborated with private laboratories in the performance of COVID-19 rRT-PCR tests, with the combined ability of all 43 public and private laboratories hitting 16,635 rRT-PCR tests per day. The increasing demand for COVID-19 tests did not seem to significantly affect influenza testing.[23] During the pandemic period from Week 6 of 2020 to Week 14 of 2021, the total number of samples received for influenza testing was 3478 and the total number of samples processed was 3447, which is equivalent to a process rate of 99.1%.[24] From Week 49 of 2018 to Week 5 of 2020 prior to the pandemic and MCO in Malaysia, the total number of samples received for influenza testing was 7224 and the number of samples processed was 6999, hence a process rate of 96.9%. While the number of samples received for influenza testing during the pandemic period was down by slightly more than half, the sample process rate was in fact marginally higher than before the pandemic.[24] Converting to the number of positive influenza cases per 100 samples processed, there were 19.2 between Week 49 of 2018 and Week 5 of 2020, whereas there were only 3.2 between Week 6 of 2020 and Week 14 of 2021. Being in the tropics, the influenza cases in Malaysia are less susceptible to seasonal variation than in the temperate regions and they have been detected all year round (Fig. 3b). In addition, the number of influenza cases in 2020 was the lowest compared to the previous three years, especially after the initiation of MCO.[24]

The study faces certain limitations due to its correlational nature. Though it shows that the influenza cases before and after the onset of COVID-19 are significantly different, it does not establish the causal relations for the reduction in influenza cases after the onset of COVID-19. The plausible causes of influenza decline were deduced from the obvious implementation of COVID-19 control measures and behavioral changes ensuing COVID-19, which are still evident to date. Due to the limited data on the frequency of sanitation, the use of hand sanitizers or the practice of hand hygiene, the use of masks, and the practices of physical distancing, this study does not examine how each of the factors contributes to the reduction of influenza cases. Similarly, the lack of data for these variables does not permit the comparison of whether the adoption or intensified adoption of these precautions would significantly reduce influenza cases. Besides, this study may not have accounted for all confounding factors such as changes in health-seeking behaviors during the COVID-19 era.

As such, future studies can aim to address the limitations by examining the causal relations between the COVID-19 control measures and the decline in influenza cases. These control measures or factors could be examined separately under controlled settings to investigate their effectiveness in controlling influenza and the underlying mechanisms. The correlational studies could be extended to different countries adopting similar COVID-19 control measures to confirm if the control measures were the contributing factors of diminishing influenza cases.

Conclusion

This study reveals that there are significant differences in the weekly cases of influenza before and after the onset of COVID-19 in Malaysia attributed probably to the COVID-19 control measures consisting mainly of physical distancing, mask-wearing, keeping of hand hygiene, and sanitization of premises, which are still widely practiced currently. The implementation of self-isolation is situational depending on the local cases of COVID-19 and, therefore, is

constrained in accounting for the consistently low weekly new influenza cases throughout the COVID-19 era. This study highlights the co-benefits of implementing COVID-19 control measures, particularly in the significant reduction of influenza. The lower respiratory tract infection associated with influenza was reported to cause 2.6 deaths per 100,000 population in Malaysia in 2017.[25] This study suggests that situational practices of physical distancing, mask-wearing, and keeping of hand hygiene during influenza seasons post COVID-19 could be beneficial and hand hygiene is a practice which could be continued in the control of influenza post COVID-19.

Author statements

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Ethical approval

Not required, as the study does not involve any human subjects.

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Competing interests

None declared.

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