

COVID-19 Review: An Epidemiological Perspective and Malaysian Scenario in Handling the Pandemic (January – May 2020)

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ABSTRACT

The pandemic of Coronavirus Disease 2019 (COVID-19) has brought much fear and anxiety worldwide due to the rapid transmission rate and mortality. The exponential surge of COVID-19 cases need to be addressed aggressively to flatten the epidemic curve. This review aims to describe the COVID-19 disease epidemiology and disease transmission, response actions taken by the authorities to control this pandemic and risk communication strategies in Malaysia. A literature search via the ScienceDirect and Google Scholar databases of published articles and official statements from the Ministry of Health, Malaysia from December 2019 to May 2020 was conducted. The first wave of COVID-19 outbreak in Malaysia started in late January involving 22 cases but the second wave involved more cases due to the massive religious gathering that occurred in late February. Malaysia implemented the Movement Control Order (MCO) on 18th March 2020 and other well-coordinated response action plans to prevent community transmission. The reproduction number (R_0) was successfully reduced from 3.6 to 0.3 due to the MCO. Malaysia's risk communication strategies that include daily press conference by the Director General of Health and dissemination of information through national television and social media, played a crucial role in dealing with the COVID-19 outbreak. In conclusion, effective response actions and mitigation plans, should be the main priorities to combat this pandemic. The immediate direction will need to be focused on development of vaccines for COVID-19. Future research should study the origin of the virus in animals and the role of comorbidities contributing to poorer prognosis.

KEYWORDS: Coronavirus, COVID-19, SARS-CoV-2, pandemic, epidemiology, reproduction number, response action, mitigation plan, Malaysia, risk communication.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak was notified in Wuhan, China on 31st December 2019 [1]. Since then, it has spread to across China and subsequently all over the world. The World Health Organization (WHO) declared this outbreak as pandemic on 11th March 2020 due to the massive spread of this disease with 118,000 cases in 114 countries and 4,291 deaths worldwide (as of 11th March 2020) [2]. Italy and Spain reported 59,138 and 28,572 cases respectively while the total number of deaths in Italy (5476 deaths) exceeded China (3276 deaths) on 23rd March 2020 [3]. In Malaysia, the first case of a patient infected with COVID-19 was reported on 25th January 2020, a Chinese citizen from Wuhan. Two deaths were

first reported on 17th March 2020. As of 10th May, there were 6656 cases and 108 deaths reported in Malaysia [4].

From microbiological perspective, SARS-CoV-2 are coronaviruses which are enveloped, non-segmented, positive-sense single-stranded RNA virus genomes. It was found to be among the largest viral RNA genome that can be up to 32 kilobases in size. The coronavirus subfamily is genotypically and serologically divided into four genera, which are the α , β , γ , and δ coronaviruses [5]. SARS-CoV-2 came from the β lineage of the beta-coronaviruses. Alpha and beta-coronaviruses mainly originate from mammals, particularly in bats, whereas gamma and delta-viruses originate from pigs and birds [6]. A recent study has also shown that the original strain initially discovered in



Wuhan, has mutated to two different strains, subsequently spreading to East Asia and Europe [7].

Main presenting features of patients at the onset of illness infected with COVID-19 are fever, cough, dyspnoea, myalgia and fatigue. Other symptoms reported by patients include headache and diarrhoea. Complications can range from acute respiratory distress syndrome, acute cardiac injury and secondary infection [8]. Since very little is known about this novel coronavirus, most researchers are working to understand the natural history of its infection. By applying the basic epidemiological triad model, we will gain a better understanding of the role and the dynamics of the components of agent (virus), host (human) and the environment in the disease transmission. This review aims to describe the COVID-19 epidemiology and disease transmission, response actions taken by the authorities to stop this pandemic and risk communication strategies during the outbreak.

METHODOLOGY

A literature search via the ScienceDirect and Google Scholar databases of published articles and official statements from the Ministry of Health, Malaysia covering the period from December 2019 to May 2020 was conducted. A search involving the use of the terms - "COVID-19" or "SARS-CoV-2", "epidemiology", "pandemic", "response action" and "Malaysia" - in titles or abstracts, was used to identify articles which covered the review objectives. Non-peer reviewed publications were excluded. This review did not require any ethical approval and statistical analysis was not conducted.

RESULTS

Epidemiology Perspective

This pandemic was postulated to have originated from the Huanan Seafood Market in Wuhan. Twenty-seven cases were found by the Wuhan Municipal Health and Health Commission on 31st December 2019 through case search and retrospective investigation. Majority of the cases had fever, and some presented with difficulty in breathing. A team of clinical medical, epidemiological and virological experts there

concluded it to be viral pneumonia [9]. Apart from seafood, the wet market is well known to sell wild and exotic animals such as marmots, snakes and bats, which are considered a delicacy in China. These animals are sold in the same market with domestic animals such as pigs and chickens. Therefore, the possibility of the virus to be transmitted from wild to domestic animals is high. Eventually, this could lead to zoonotic disease when transmission of disease from animals to humans is successful. However, further investigations are still in progress to determine the definitive animal host and reservoirs for COVID-19 [10].

Malaysia's first case was notified on 23rd January 2020 when Singapore notified a positive COVID-19 case, a 66-years old Chinese citizen from Wuhan. Eight close contacts of that case travelled to Johor Bahru, Malaysia. The Johor Health State Department immediately responded, and all the close contacts were traced and tested at National Public Health Laboratory (NPHL). Out of the eight contacts, three were tested positive for COVID-19 on 25th January 2020. On the same day, The Malaysia Ministry of Health (MOH), reported the 4th positive case from its 23 Patient-Under Investigation (PUI), a Chinese citizen that was not related to the contacts. All four positive cases were treated in isolation wards and they were in stable condition. A total of 17 close contacts of the 4th case was tested negative and discharged. This first wave of the COVID-19 outbreak in Malaysia amounted 22 cases fully recovered and discharged on 27th February 2020 [11, 12, 13, 14] (Figure 1).

A number of new cases were reported after the first wave such as from PUIs, close contacts, Influenza-Like-Illness (ILI) and Severe Acute Respiratory Syndrome (SARI) surveillance and humanitarian missions but the second wave of COVID-19 outbreak occurred after a massive religious event gathering (Perhimpunan Tabligh) at Masjid Seri Petaling, Kuala Lumpur that was held between 27th February 2020 till 3rd March 2020 [15]. This gathering involved more than 15,000 people from Malaysia and overseas. After the event, the participants travelled back to their hometowns all over Malaysia and this played the main factor in the spread of the disease in the community during the second wave.

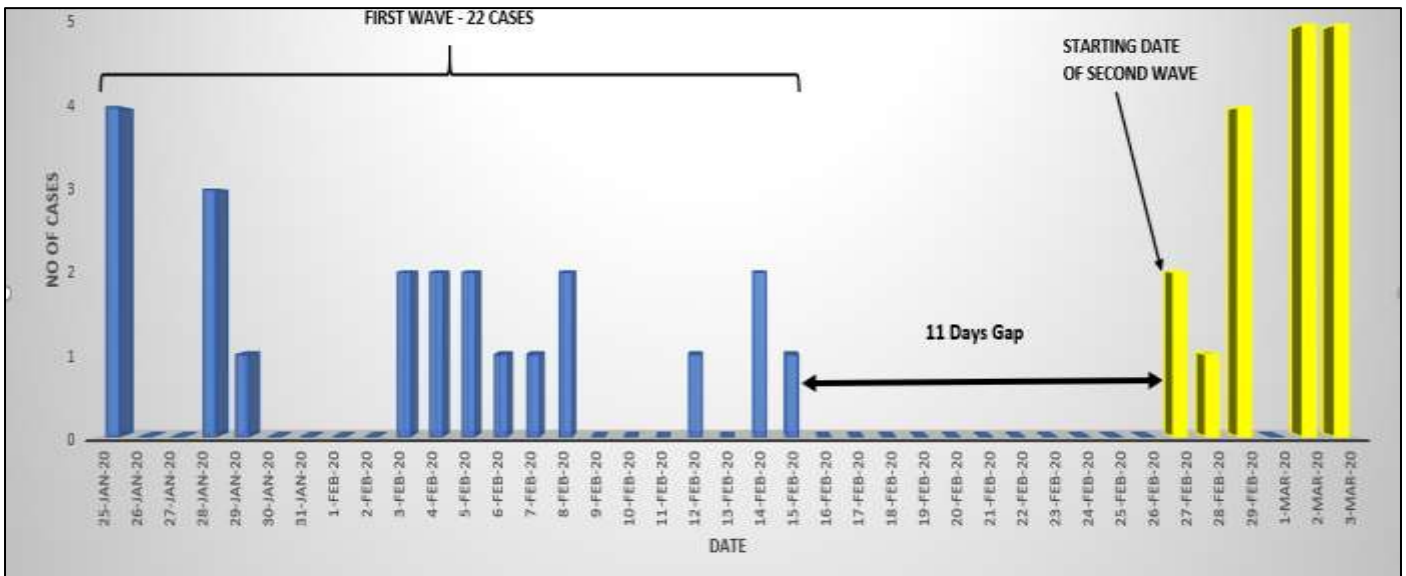


Figure 1 Chronological order of COVID-19 cases in Malaysia during the first wave [65].

This triggered the country’s response to the COVID-19 outbreak. As of 17th March 2020, a sudden surge up to 673 positive cases and the first two deaths were reported in Malaysia. The Malaysian government, following advisory given by the Ministry of Health (MOH), responded immediately by initiating the Movement Control Order (MCO) from 18th March 2020 till 31st March 2020 to curb further disease transmission in the population [16]. A two-week extension was subsequently announced from 1st April 2020 to 14th April 2020, or known as second phase [17], and the third phase was further extended to 28th April 2020 [18].

The fourth phase continued till 3rd May 2020. The MCO is a vital strategy to break the human-to-human transmission in the community and prevent sudden surge of cases, thus avert a massive burden to the healthcare system. Conditional Movement Control Order (CMCO) was implemented from 4th May 2020 to 9th June 2020. The CMCO was implemented to re-open several sectors of the economy in a cautious and controlled manner. However, public gatherings and activities that expose the public to the risk of COVID-19 infection are still prohibited. As of 10th May 2020, there were 6656 cases and 108 deaths reported in Malaysia (Figure 2 & Table 1) [4].

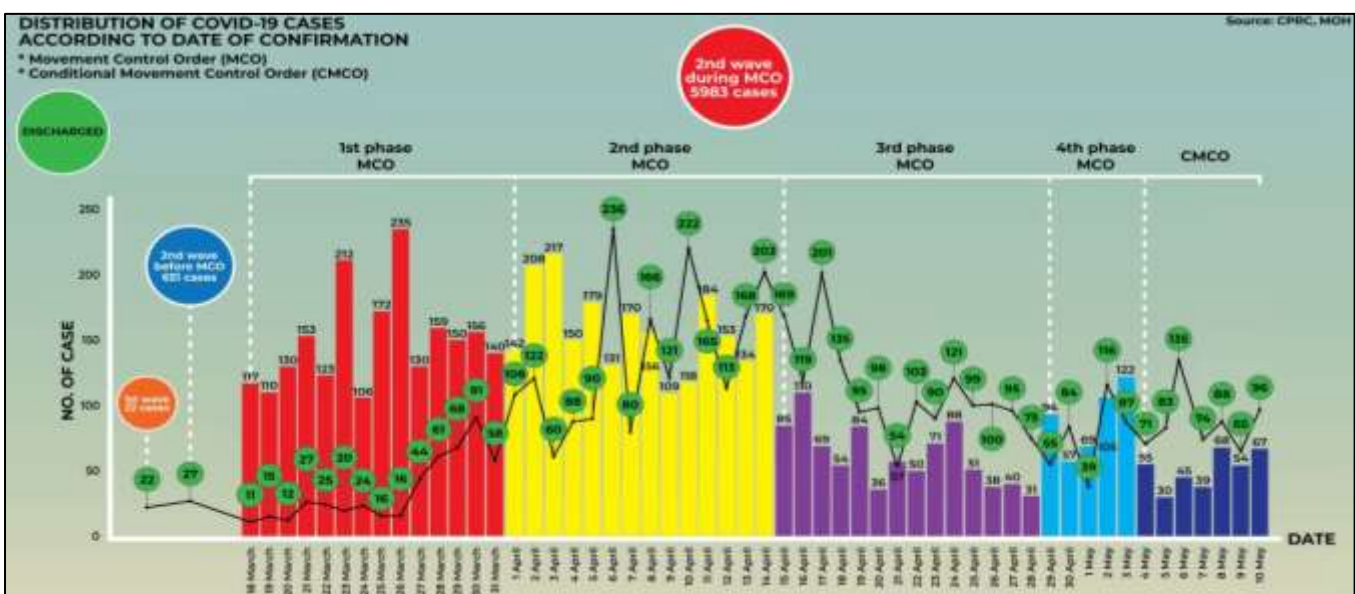


Figure 2 Trend of cases in Malaysia from 18th March 2020 till 10th May 2020 [4].

Table 1 Characteristic of confirmed cases in Malaysia (As of 10th May 2020) [4]

CONFIRMED CASES OF COVID-19					TOTAL
SOURCE	Patient Under Investigation (PUI) / Close Contact	Cluster from religious gathering at Sri Petaling	Surveillance	Imported cases	
NO. OF CASES	3765	2345	206	340	6656

Epidemiological Triad

The phylogenetic network approach was suggested to recognize the evolution of COVID-19 coronavirus within humans, amid the possibility of high viral pathogenicity, to result in a higher level of virus shedding [5, 7]. In infectious disease epidemiology, basic reproduction number, R_0 , indicates the transmissibility of a virus, representing the average number of new infections (infectee) generated by an infectious person (infectior) in a totally naïve population [19]. If the R_0 in the population is greater than 1, the infection will spread exponentially, but not if $R_0 < 1$ [20].

If one person develops COVID-19 and transmits it to two others, the R_0 is 2 (Figure 3). It was revealed that R_0 for COVID-19 in China ranged between 1.4 to 6.49 with mean of 3.28, which exceeded the WHO estimation of 1.4 to 2.5 [19]. The R_0 of COVID-19 is relatively higher than Severe Acute Respiratory Syndrome coronavirus (SARS-CoV, 3.0) [21] and Middle East Respiratory Syndrome Coronavirus (MERS-CoV, <1) [22]. R_0 has reduced from 3.6 to 0.3 following MCO implementation in Malaysia. If the MCO were to be lifted too early, the epidemic curve may result in an exponential increase [23].

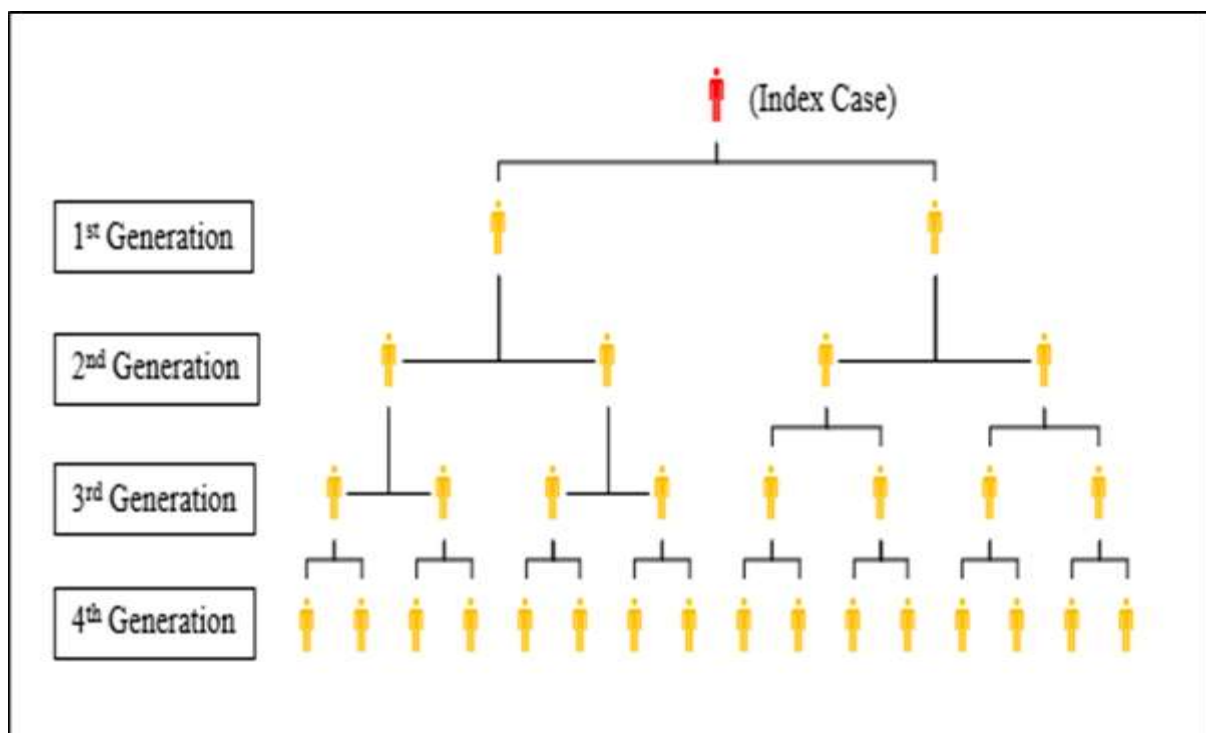


Figure 3 An illustration of four generations of infection, assuming the R_0 to be at 2.0, in which each infected person (infectior) will infect two people (infectee). One index case will be able to infect 30 people if the transmission is ‘allowed’ up to 4th generation. The mean serial interval for COVID-19 is between 4 and 7.5 days [30, 34].

COVID-19 is spread mainly from person to person who are in close contact and through respiratory droplets produced when an infected person coughs or sneezes [24]. Droplet transmission is typically limited to short distances, generally less than 2 meters [25]. The infected droplets can land on inanimate surfaces and be a source of transmission in the general population. It was reported that SARS-CoV could persist on metal and plastic up to 5 and 9 days, respectively at room temperature [26]. It was also reported that the longest viability (half-life) of the SARS-CoV-2 virus on stainless steel was 5.6 hours and that on plastic was 6.8 hours respectively [27]. Therefore, it is extremely crucial for regular disinfections to be done on these common contact surfaces such as in supermarkets or elevators.

High population density was also reported to increase the chances of the disease spreading in the community due to high chance of a naïve host being infected through direct or indirect contact [28]. The human behavioural factor in adhering to public health advices, for example strict hand washing, social distancing and mandatory quarantine contributes to disease transmission [29]. As such, every individual shall play his role in protecting himself and the community.

The incubation period for COVID-19, which refers to the time between contracting the virus and the

manifestation of sign and symptoms varies due to limited evidence [29]. In China, it was reported that the mean incubation period was 5.2 days among COVID-19 patients in Wuhan [30], and 6.4 days for those detected outside Wuhan [31]. As a comparison, SARS-CoV has a mean incubation period of 5 days [32] while mean range for MERS-CoV was between 6.4-7.1 days [33]. These values show that there is minimal difference in the mean incubation periods between COVID-19, SARS-CoV and MERS-CoV.

Furthermore, another important terminology in disease transmission is serial interval. Serial interval refers to the time from illness onset in a primary case (infector) to illness onset in a secondary case (infected) [34]. This interval is commonly used in infectious disease control and surveillance. Several epidemiological studies revealed the serial interval for COVID-19 with mean of 7.5 days among Wuhan patients [30] and the median of 4.0 days in another study [34]. In comparison to other coronaviruses, it was documented that the mean serial interval was 8.4 days for SARS-CoV [35], while for MERS-CoV, the mean range of serial interval is between 6.8 to 12.6 days [36, 37]. A shorter serial interval than the incubation period indicates that pre-symptomatic transmission is likely to have occurred more frequently than symptomatic transmission [34].

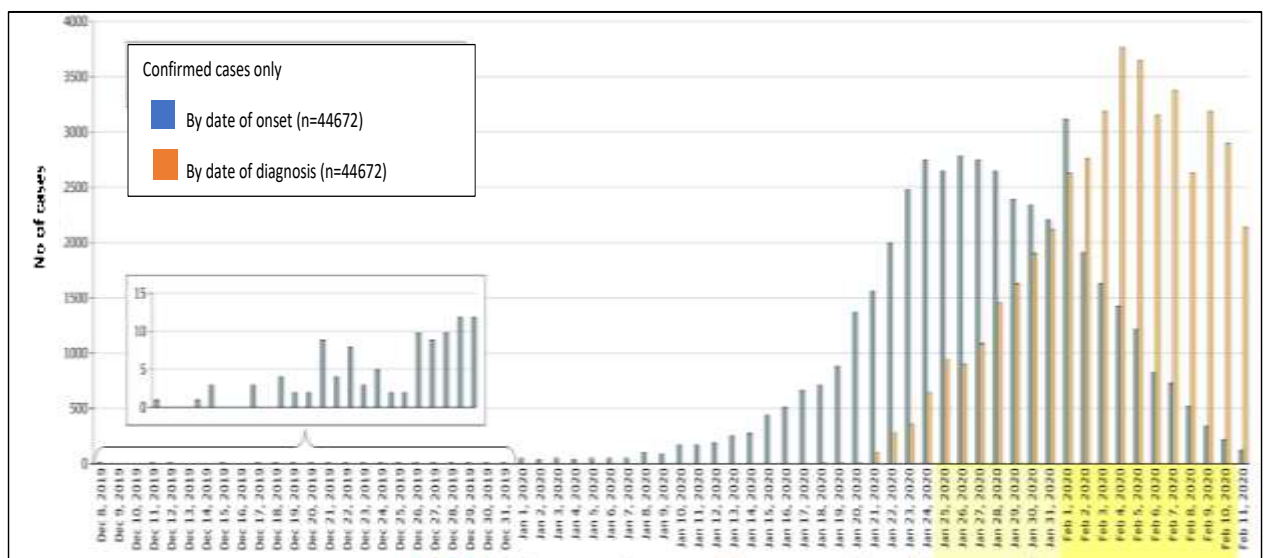


Figure 4 Epidemic Curve of COVID-19 in Wuhan, China from December 8, 2019 to February 11, 2020. [38].

Epidemic Curve

In a case series studied in Wuhan, the epidemic curve revealed a mixed outbreak pattern. Early cases gave a picture of a continuous common source, as a result of zoonoses that was most likely originated from the Huanan Seafood Wholesale Market, and later cases revealed a propagated source pattern as the human-to-human transmission of the virus increased (Figure 4) [38].

As of 28th April 2020, a total of 2,924,722 cases were reported with 200,617 deaths worldwide. The cumulative number of cases reported plotted by WHO

is shown in Figure 5. Initial outbreaks were observed in Western Pacific countries, mainly in China. In early March, cases began to spread to Europe and the Americas started reporting cases of COVID-19 in the middle of March 2020 [39]. Every country aimed to flatten the epidemic curve to avoid the sudden surge in COVID-19 cases and ease the demand on the healthcare system [40]. However, some countries have seen their healthcare systems stretched to the maximum capacity even after movement restrictive order was implemented due to the overwhelming number of critical cases admitted to hospitals such as in Lombardy, Italy [41].

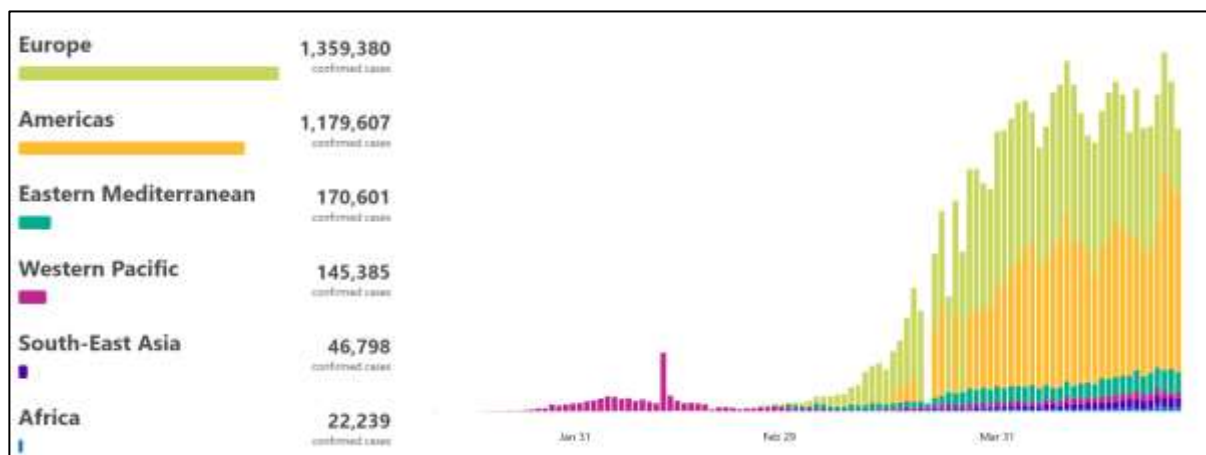


Figure 5 Cumulative number of confirmed cases of COVID-19 worldwide according to region up to 28th April 2020 [39].

Investigation of cases and contact tracing

The objective of an investigation of a suspected COVID-19 case is to rapidly detect cases, trace the human-to-human transmission, delay spread of disease and prevent outbreaks. WHO states that case definitions should be adapted accordingly from country to country as the epidemiological patterns of COVID-19 may be different from one geographical area to another. Contact tracing should identify all social, family, work and healthcare worker contacts. Line listing with all the relevant information should be thoroughly documented in the contact tracing process [42]. In Malaysia, PUI of COVID-19 case definition changes with the evolving outbreak and as of 28th April 2020, it is defined as a person with an acute respiratory infection (sudden onset of respiratory infection with at least one of the

symptoms: shortness of breath, cough or sore throat) with or without fever AND

- (i) travelled to / resided in a foreign country within 14 days before the onset of illness OR
- (ii) close contact in 14 days before illness onset with a confirmed case of COVID-19 OR
- (iii) attended an event associated with a known COVID-19 outbreak.

A confirmed case of COVID-19 is a person with laboratory confirmation of infection with the COVID-19; where 43 laboratories established in various sectors to provide the laboratory test [43]. The effective collaborative effort between the Malaysia MOH, police and use of big data analytics, has produced an excellent job in tracking and tracing cases; and resulted in as high as five generations of contacts identified.

Response Action for COVID-19 Community Transmission

WHO has detailed out priority areas of work to be conducted immediately in the event of community transmission of COVID-19. They include:

- Scaling up emergency response mechanisms.
- Active risk communication and community engagement to the public.
- Active case finding, contact tracing, quarantine of contacts and isolation of cases.
- Monitoring of disease activity through existing and enhanced surveillance system.
- Advocating public health measures such as hand hygiene and social distancing.
- Training staff in infection, prevention and control of COVID-19.
- Implement health facilities surge plans.
- Implement prioritized testing and measures to reduce spread of disease.
- Screening and triaging of patients at all points of health care system.
- Scaling up surge plans for health facilities and ad-hoc community facilities.
- Manage COVID-19 cases according to severity and risk factors. [44]

In China, the control measures started during the Lunar New Year Holiday. Travel ban was implemented on 23rd January 2020. However, about 1/3 out of 5 million people left Wuhan before the travel ban. This could have worsened the outbreak as there will be those who are latently infected that can come back to Wuhan after one week and infect others. Therefore, the Chinese government extended the holiday period to 10th March 2020 for Hubei province and hoped that the long holiday period would be able to cover the suspected incubation period of COVID-19 [45]. Simultaneously, a strict lockdown of Wuhan and nearby cities was implemented [46]. Other measures enforced include discouraging mass gatherings; cancelling or postponing large public events; closing of schools, universities, government offices, libraries, museums, and factories. Positive cases were isolated in hospitals while mild and asymptomatic infections were quarantined [45].

The Malaysia MOH has drafted a comprehensive response plan to this pandemic based on WHO recommendations and tailored to the Malaysian setting, which was carried out by the government. The management of COVID-19 in the country follows the guidelines by the MOH that includes the case definition of COVID-19, management of PUI, screening and triaging, clinical management of confirmed case, infection prevention and control measures, surveillance of COVID-19, laboratory testing procedures, management of travellers from foreign country, strengthening the Malaysian borders, management of healthcare worker, management of quarantine centres and mental health and psychosocial support in COVID-19 [43].

For Malaysia, the government implemented the MCO from 18th to 31st March, extended from 1st to 14th April 2020, further continued from 15th to 28th April 2020 and subsequently extended from 29th April to 12th May 2020. This strategy was essential to break the chain of transmission in the community and avoid sudden exponential spike in COVID-19 cases in the country. People were advised to stay at home, practice social distancing for at least 1 meter from each other and wash hands regularly with soap or use hand sanitizers. The police force and the army contributed by conducting roadblocks at major roads to ensure that people did not go out unnecessarily from their house. Points of entry at the Malaysian borders were tightened. Malaysians were not allowed to leave the country during this MCO period and Malaysian returnees were tested and quarantined for 14 days. The MOH also listed all the districts in Malaysia with their number of COVID-19 cases. A district with more than 40 cases was considered as a hotspot district. Furthermore, if a particular locality in that district was found to have a sudden increase in cases, enhanced MCO was substantiated. For example, there were two areas in Kluang, Johor (Bandar Baru Dato' Ibrahim Majid and Kampung Dato' Ibrahim Majid) that reported a spike of 74 positive cases in one day. Enhanced MCO (EMCO) refers to enforcing strict control of movement of that particular locality in which the community identified are not allowed to leave the area for 14 days. These are to prevent the spread of the disease to outside of the area, break the chain of disease transmission, conduct active case detection from house

to house and perform disinfection activities. A medical base was set up and food was supplied to the community during the whole 14 days through the Welfare Department [47].

Apart from that, the Malaysia MOH has prepared extensively to combat this pandemic by:

- i. recruiting more medical personnel from various backgrounds or specialities to help with the existing workforce through short-term contracts and encouraging volunteers with medical training to join the MOH in any areas that they want to contribute.
- ii. adding more supply of equipment such as ventilators and Personal Protective Equipment (PPE). Donations, especially PPE for usage by front liners at health facilities, from non-governmental organizations (NGOs) and any individuals were overwhelming, showing the good solidarity of all Malaysians.
- iii. increasing the number of screening centres, quarantine centres, designated laboratories, COVID-19 dedicated hospitals and number of beds. For example, the MOH increased the hospital capacity for screening of COVID-19 from 57 to 70 hospitals, numbers of

managing cases from 26 to 38 hospitals and the number of dedicated beds to treat COVID-19 patients increased to 3994 beds. MOH training institutes provided another 1937 beds and Malaysia Agro Exposition Park Serdang Convention Centre provided spaces for 600 beds as step-down care for asymptomatic and mild cases. The MOH has successfully organized and set-up 43 laboratories to enable more testing to be done in the community. These include healthcare centres from the private sector and institutes of higher learning and Armed Forces.

- iv. conducting risk reduction programmes at districts level according to red, orange, yellow and green zones.
- v. performing targeted screening (emphasis on high-risk groups) such as those who attended the large religious gathering and religious (Tahfiz) schools. Malaysian citizens who come back from overseas are screened and placed at designated quarantine centres for 14 days to prevent spreads of imported cases.
- vi. collaborating with various agencies in conducting health education and updating information through all media resources [48] (Table 2).

Table 2 Summary of Public Health Actions in Combating the Covid-19 Pandemic in Malaysia (As of 30 April 2020). [43]

Case	Contacts	Carriers	Community	Healthcare settings and Personnel
Definition:				
A confirmed case is a person with laboratory confirmation of infection with the COVID-19.	Close contact is defined as: <ul style="list-style-type: none"> • Health care associated exposure without appropriate PPE (including providing direct care for COVID-19 patients, working with health care workers infected with COVID-19, visiting patients or staying in the same close environment of a COVID-19 patient). • Working together in close proximity or sharing the same classroom environment with a with COVID-19 patient • Traveling together with COVID-19 patient in any kind of conveyance • Living in the same household as a COVID-19 patient 	A person with inapparent infection who is capable of transmitting COVID-19 to others. Category: <ul style="list-style-type: none"> i) Asymptomatic or healthy carriers are those who never experience symptoms despite being infected. ii) Incubatory carriers are those who can transmit the agent during the incubation period before clinical illness begins. **iii) Convalescent carriers are those who have recovered from their illness but remain capable of transmitting to others. **iv) Chronic carriers are those who continue to harbour the virus, for months or years after their initial infection. [64] 	Refers to a collection of people who shared some similar characteristics. As for COVID-19, community refers to Malaysia's general public, state, district or housing areas populations.	Healthcare personnel are those who are involved in treating patients, screening, taking clinical samples, handling samples, do active case detection or tracing contacts.
Person Under Investigation (PUI) of COVID-19 is defined as person with an acute respiratory infection (sudden onset of respiratory infection with at least one of the symptoms: shortness of breath, cough or sore throat) with or without fever AND <ul style="list-style-type: none"> (i) travelled to / resided in foreign country within 14 days before the onset of illness OR (ii) close contact in 14 days before illness onset with a confirmed case of COVID-19 OR (iii) attended an event associated with known COVID-19 outbreak. 				

(**Note: Carrier state for COVID-19 is yet to be determined for these 2 categories)

Public Health Actions				
Case	Contacts	Carriers	Community	Healthcare settings and Personnel
Set and updating Case Definition given by the World Health Organization and tailor it to the Malaysian setting to diagnose or categorize type of cases (eg: PUI, suspected and confirmed)	Contact Tracing – Public Health Medicine Specialist will get the contact list from case, organizers or employers. Aim for early detection of cases and stop disease spread.	Mass targeted approach screening in Enhanced Movement Control Order (EMCO) areas and certain identified outbreak clusters at red zones areas.	Collaboration with various agencies in conducting health education and providing updates regarding COVID-19 using mass and social media.	Training to medical personnel regarding PPE, contact tracing and sampling methods.
Active Case Detection including at borders and points of entry by taking oropharyngeal and nasopharyngeal swabs.	Detection by oropharyngeal AND nasopharyngeal swabs for potential incubatory case or carrier. At first encounter, if positive he/she will be admitted for isolation and the negatives will be put under quarantined for 14 days. Those at quarantine centre will be tested again on Day 13. If positive, will be considered as asymptomatic case (PUS).	Enhanced surveillance of Influenza-like Illness (ILI) and Severe Acute Respiratory Illness (SARI) by health clinics personnel.	Mass targeted approach screening among community in Enhanced Movement Control Order (EMCO) areas.	Increasing designated COVID-19 treating hospital, number of hospital beds, ICU beds and screening centres throughout the country.
Case investigation to identify possible exposure and spread; and get contact lists.	Quarantine (Absolute) at designated quarantine centres (earlier contacts were allowed to self-quarantine at home with Home Surveillance Order and provided with Home Assessment Tool) for a duration of 14 days as a respiratory precaution. This is under Act 342. Contacts only to be released from quarantine order when second nasopharyngeal swab is negative.	Follow-up post-convalescent cases for detection of carrier state.	Enhanced surveillance of ILI and SARI by health clinics and hospitals.	Coming up with Standard Operating Procedure (SOP) on triage, sampling and PPE (proper usage, donning and doffing).
Airborne infection isolation room (AIIR) i.e. negative pressure isolation room with anteroom for confirmed or possible cases on ventilator and for conducting aerosol generating procedure.	Daily medical surveillance for development of symptoms.		Order premises or any part thereof to be closed under the Act 342, Prevention and Control of Infectious Diseases Act 1988. The premises include schools, universities, factories etc	Increased laboratory capacities nationwide to perform COVID-19 testing (eg: Identified and designated 43 laboratories nationwide to do testing of COVID-19 samples).
Disinfection of confined places where cases had shared with others e.g. home, workplace, mosques, church, airplane, meeting rooms etc.	Disinfection of contacts' surroundings or environment.		Movement Control Order (Act 342) and Enhanced Movement Control Order at localities found to have clusters of COVID-19 outbreak.	Increasing supply of equipment such as PPE for healthcare workers and ventilators for usage in Intensive Care Units nationwide.

Clinical management in COVID-19 designated hospitals.

At least three days (72 hours) have passed since recovery of symptoms (defined as resolution of fever without antipyretics and improvement in respiratory symptoms [eg: cough, shortness of breath]) AND
 At least 2 samples (Oropharyngeal/Nasopharyngeal swab) are negative more than 24 hours apart. The samples are to be taken after day 13 of illness.

Screening and quarantine of Malaysian citizens coming back from overseas at designated quarantine centres for 14 days.

Infection, prevention and control measures in all healthcare facilities.

Strengthening the Malaysian borders by denying access of foreign nationals into the country.

Increasing designated quarantine centres in the country and collaborate with National Disaster Management Agency (NADMA) and Ministry of Tourism to identify hotels that are suitable to be converted to quarantine centres.

Movement Control Order (MCO) of the community which includes prohibition of movement of persons and mass gatherings and operation of non-essential services.

Public cleaning and disinfection (done by local government and other governmental agencies)

Classification of districts according to red, orange, yellow and green zones.
 Note:
 Red zone = 41 cases and above
 Orange zone = 21 -40 cases
 Yellow zone = 1 – 20 cases
 Green zone = No cases

Recruiting more medical personnel from various backgrounds to help with the existing workforce either through volunteer initiative or offering short-term contracts to private healthcare personnel to join the government sector.

Risk Communication

In times of disaster such as the COVID-19 pandemic, public should be well-informed regarding the disease, risk factors and preventive measures that can be taken. Relevant information that are disseminated swiftly, regularly and through easily accessible platforms in a clear manner that will empower the public knowledge about the disease.

Risk communication play a crucial role in any response action plan for an outbreak situation. It not only involves passing of updates regarding the public emergency from the top experts to the population, but also includes the real-time exchange of information, advice and opinions between specialists in various fields, government officials, community leaders and the general population. During major disease outbreaks and pandemics, risk communication strategy that is well-planned can go a long way in ensuring containment process run smoothly [49]. It is vital to identify target audiences in a particular country such as policymakers, local leaders, women and youth groups, religious groups, non-governmental organisations, health care workers and volunteers. The main objective is to reach for the targeted audience with the correct method of risk communication to get the desired outcome [50]. For example, the younger generations might absorb more knowledge relating to COVID-19 through social media platforms, while senior citizens who are not well versed in the information technology landscape might prefer getting information through mainstream media such as national TV and printed media.

In Malaysia, risk communication was established through public trust via multiple channels to cater to all layers of the population. Usage of social media was fully capitalized by using a variety of platforms. They included the (i) Telegram, where the Crisis Preparedness and Response Centre (CPRC), Malaysia MOH, provided consistent updates regarding the COVID-19 situation in Malaysia and worldwide; (ii) Malaysia MOH Twitter account; (iii) MOH Instagram account; (iv) Facebook, where the MOH Malaysia post regular updates and latest information at its page. Moreover, the Facebook Live Sessions was conducted daily including 24-hour hotline to address any queries from the public regarding the disease.

An example of excellent risk communication was the daily press conference conducted by the Malaysia MOH Director General (DG) of Health. Detailed daily updates were broadcasted live through national television and social media on the COVID-19 situation in Malaysia which include the number of recovered cases, reported new cases, number of patients in Intensive Care Units (ICU), number of deaths, clusters and health advisory. The DG of Health also dedicated his time for question and answer session with the reporters in every press conference session. Other risk communication strategies that were carried out by MOH involved disseminating health education through radio and television and providing assistance through telephone. All MOH healthcare facilities and the CPRC MOH Hotline are always available to receive call from the public. A Virtual Health Advisory was also created by MOH for health advisory purposes related to COVID-19 such as the Doctor on Call service.

DISCUSSION

Effectiveness of Malaysia's Response Compared to Other Countries

Responses from countries all over the world were mainly based on the country's population and healthcare system, which includes infrastructures and manpower. China's response was used by many countries as reference as it was where the outbreak of COVID-19 first took place [51].

In Taiwan, the government has learned from its SARS experience in 2003 and established a public health response mechanism for enabling rapid actions for the next crisis. They have a National Health Command Center (NHCC) that focuses on large-outbreak response and acts as the operational command point for direct communications among central, regional, and local authorities. The NHCC rapidly produced and implemented at least 124 action items between January 2020 to February 2020 and managed to keep the number of confirmed cases low (440 cases as of 21st May 2020) [52]. Many of these responses such as tight border control, quarantine of suspicious cases and risk communication to the public are carried out effectively by the Malaysian Government. However, the use of big data analytics in Taiwan is the unique

method that they implemented. For example, Taiwan leveraged its national health insurance database and integrated it with its immigration and customs database to begin the creation of big data for analytics. Real-time alerts were then generated during a clinical visit based on travel history and clinical symptoms to aid case identification [52].

South Korea is one of the countries that were affected during the early stages of the pandemic. To curb the disease transmission, multi-sectorial approach that include health-care professionals, committees, and governments have conducted extensive COVID-19 screening, effective patient triage, the transparent provision of information, and the use of information technology. About 600 screening sites were established that include health-care clinics, drive-through centers and walk-in screening sites [53]. Malaysia's targeted screening approach to high risk groups such as tahniz group, EMCO areas and foreign workers, is slightly different from South Korea's method but has proved to be successful in controlling the outbreak.

However, there are some lessons to be learned from countries which reported a high number of COVID-19 cases and total number of deaths. In the United States (US), as of 1st April 2020, 72 days after the first reported case of Covid-19, 33 states and dozens of localities had issued stay-at-home orders but some orders lack strong enforcement mechanisms. Many jurisdictions continue to permit widespread noncompliance such as crowded spring-break beaches, busy stores selling nonessential goods and children congregating in public parks. This federalism type of US governance lead to a mixed response actions from all the states and contributed in making US the country with the highest total number of cases in the world (as of 21st May 2020) [54]. Malaysia's centralized comprehensive response action plans have served the country well by curbing the COVID-19 pandemic.

Lastly, in the United Kingdom (UK), up to the 2nd week of March, there were no orders from the government to ban mass gatherings and businesses were running as usual. Mixed messages were given to the public regarding non-essential travel, avoidance of social gathering and operation of non-essential businesses. The UK public health community have been sending messages of increasing concern as the lack of

governmental action was out of step as compared to other European nations at that time. These may have contributed to the increase of the disease transmission in the UK [55]. Malaysia's response plans have been done in a swift manner and messages conveyed clearly to the public by the Ministry of Health, Malaysia.

Future Directions in Handling the COVID-19 Pandemic

As yet, researchers worldwide are working on the development of vaccine for COVID-19. The vaccine development explores different strategies such as inactivated virus vaccines, attenuated virus vaccines, subunit vaccines, viral vector vaccines, DNA vaccines and mRNA vaccines [56, 57]. A group of researchers in China have started a single-centre, open and dose-escalation Phase I clinical trial for recombinant novel coronavirus vaccine (adenoviral vector) among healthy adults aged between 18 and 60 years, and it is expected to complete on 31st December 2020 [58]. Another study in the USA started the phase I, open-label, dose ranging clinical trial in males and non-pregnant females aged between 18 and 55 years of age, and it is expected to be completed on 1st June 2021 [59]. Thus, the long road to vaccine development (potentially 12 months or more), hindered by many challenges [60], warrants prompt public health measures in breaking the transmission chain.

Several ongoing public health strategies executed in Malaysia have demonstrated significant results and could be further enhanced. They include: (i) the track and trace strategies, (ii) law enforcement to enhance MCO compliance, (iii) information exchange between countries on the experience in tackling the infections, (iv) policies or guidelines to be implemented for post-MCO phase, (v) foreigner entry and exit requirements, and (vi) community engagement. In future, precision or localised MCO in the districts with high COVID-19 incidence density could be an alternative to nationwide lockdown, in view of the zone-coding system established [61]. The application of digital contact tracing, such as the MySejahtera application, is also deemed effective to improve case detection, isolation and swift treatment, hence decreasing the overall attack rate [62].

Firstly, more studies need to be done to determine what animals are the origin or the intermediate hosts of the virus, and the human-animal transmission route is yet to be proven [63]. Besides that, future research should investigate the natural history of the disease, as the available evidence is vague and scarce. It is well-known that those with chronic diseases such as diabetes mellitus, hypertension and obesity are more likely to have poorer prognosis, but researchers need to go into more detail to see the clinicopathology aspects of the role of these comorbidities contributing to poorer prognosis. Children, being the vulnerable group, when infected with COVID-19 has generally shown mild symptoms. Therefore, studies among children can provide important epidemiological pattern of COVID-19 in these population.

CONCLUSION

In summary, it is vital for health practitioners to fully understand the epidemiology of COVID-19 as the spread of the disease does not show any signs of slowing down. Effective response actions and mitigation plans, as carried out well by Malaysia, should be the main priorities to combat this pandemic.

Conflict of Interest

Authors declare none.

Author's Contributions

ZIA drafted the first version of the review, finalized the Discussion section and Figures. CXW critically appraised the studies and contributed to the Results section. MM created the Tables and contributed to the Results section. MSAS contributed to the Introduction section and References. MRI and NI critically appraised the studies. All authors edited and approved the final version of the manuscript.

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