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COVID-19 in Hong Kong – Public health, food safety, and animal vectors perspectives

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ABSTRACT

The coronavirus disease 2019 (COVID-19) pandemic, caused by infection with a novel coronavirus (severe acute respiratory syndrome coronavirus 2, SARS-CoV-2), has led to escalating morbidity and mortality in all nations and cities. SARS-CoV-2 lies within the same coronavirus family as SARS-CoV (2003) and MERS-CoV (2012), though there are genetic and epidemiological differences between the viruses, as well as different clinical presentations in the patients. Despite this, Hong Kong has so far managed to control the pandemic very successfully. Here we offer a Hong Kong perspective on different aspects of the pandemic virus (SARS-CoV-2) and the disease: public health (diagnosis and control), food safety (reducing transmission in the workplace) and animal vectors (controlling potential reservoirs of the virus and their movements).

1. Introduction

The COVID-19 pandemic has caused escalating morbidity and mortality in all nations and cities (Hon and Leung, 2020; Hon et al., 2020a). The pandemic is now nearly one year old since it was initially reported in December 2019. In this article, we share three perspectives on the novel SARS-CoV-2 and the coronavirus disease 2019 (COVID-19). The three perspectives are Public Health, Food Safety and Animals as potential vectors.

2. COVID-19 in Hong Kong: public health perspectives

Hong Kong, a densely populated Asian city (ca. 7.5 million living in an area of 1106 sq.km), having been through the first traumatic SARS outbreak in 2003, as well as pandemic influenza A/H1N1/2009 on the background of various avian influenza (A/H5N1 and A/H7N9) alerts over the past 20 years, has managed to contain the pandemic thus far, due to swift and decisive measures as well as a strong supportive community response. There are a few useful observations and local public health experiences to share.

First, Hong Kong has one of the lowest levels of COVID-19 related mortality and morbidity among all industrialized nations (Johns

Hopkins University, 2020). Secondly, the city has a low proportion of confirmed paediatric cases (≤ 18 years, 9%). There has been no mortality or critically ill paediatric cases nor inflammatory multisystem syndrome (PIMS) associated with COVID-19 that have been reported among Asians in Western countries (Centers for Disease Control, 2020; Shen et al., 2020; Lu et al., 2020; Rangel et al., 2005; Campbell and Sample, 2020; Public Health England, 2020). Thirdly, at the beginning of July 2020, there have been no tragic outbreaks in aged-care facilities or major outbreaks of community transmission of SARS-CoV-2 in Hong Kong. We would like to share our successful experience to help contain this pandemic (Table 1).

During this pandemic, Hong Kong has managed to avert a major coronavirus outbreak without resorting to a complete lockdown, through a combination of intervention measures including strict isolation restrictions, strong community response (including social distancing, widespread mask-wearing, flexible working hours), enhanced surveillance programme and vigilant contact tracing (Cowling et al., 2020).

The strategies used in Hong Kong are different from countries that have failed to prevent widespread community outbreaks resulting in the need to implement stringent lockdown strategies (Melnick and Ioannidis, 2020; Pachetti et al., 2020). There are a number of key factors

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fundamental to Hong Kong's successful experience in the current COVID-19 especially during the first 6 months of the pandemic (Centers for Disease Control, 2020; Lam et al., 2020). They include: 1) enhanced surveillance and contact tracing, through which many COVID-19 cases were detected by the local Center of Health Protection; 2) timely border controls, screening and surveillance to prevent importation of cases by screening asymptomatic inbound travelers; 3) strict infection control measures, whereby all suspected and confirmed patients are placed under isolation and admitted to the hospital, and only discharged if they are asymptomatic with either two negative COVID-19 tests 24 h apart or tested positive for SARS-CoV-2 antibody; 4) training and adequate personal protective equipment for healthcare workers, which has successfully prevented healthcare-related transmissions; 5) enhanced population preparedness after the SARS outbreak where Hong Kong's population is acutely aware of the need to improve personal hygiene and maintain social distancing; 6) the city's purpose-built infectious disease center with the capability and capacity to handle novel respiratory viruses; the center was built as a result of the earlier SARS-CoV-1 in the 2003 outbreak (Lam et al., 2020).

The city is aware that the COVID-19 pandemic will likely continue for the foreseeable future, and we remain vigilant as countries around the world attempt to strike a balance between resuming socio-economic activities and preventing subsequent outbreaks. The outbreaks in our community in July proved to be of strong concerns, which led to the reinforcement of social distancing and public health measures. At present, the key challenges are to minimise the socio-economic impact on all strata of the community as well as to address the more insidious psychological and physiological consequences of a prolonged 'new normal' on the population.

3. COVID-19 and food safety

The SARS-CoV-2 pandemic has caused numerous medical and socioeconomic issues and the list is increasing (Hon et al., 2020b). Towards the end of May, a new local COVID-19 cluster originated from a woman - working in a logistics warehouse - who was responsible for sticking labels on pre-packaged fruits and vegetables imported from the United Kingdom (Centers for Disease Control, 2020; Cheung et al., 2020). She became critically ill and was admitted to an intensive care unit. As she did not have any travel history, healthcare workers who managed her case were initially not alerted to the possibility of COVID-19 and did not wear full personal protective equipment. Two of her co-workers then also tested positive for COVID-19, which may suggest workplace-related transmission. A remote possibility is that the virus might have been acquired from the packaging of the imported food from a COVID-19-affected nation.

The paramedic who cared for this patient also tested positive for COVID-19 (as well as being the first healthcare worker infection in Hong Kong), making imported food and/or their related packaging possible sources of SARS-CoV-2 despite negative swabs from environmental and package sampling (Cheung et al., 2020). The reasons are as follows. First, the SARS-CoV-2 virus is highly stable at 4 °C, with only a minimal reduction of infectious titre after 14 days, and cargo used to transport fruit and vegetables is usually set below 10 °C (Chin et al., 2020; ZIM Integrated Shipping Services Ltd, 2020). Second, SARS-CoV-2 can remain viable for up to 72 h on plastic and stainless steel, and up to 24 h on cardboard, all of which are commonly used in the process of food packaging (van Doremalen et al., 2020). Third, only a limited number of food packaging samples (11 in total) were tested in this index case, which might not be sufficient to pick up the potential source of infection (Cheung et al., 2020).

Later, in June 2020, China found the trading sections for meat and

Table 1
COVID-19: The Hong Kong perspective 2020.

Perspective	Hong Kong	Global	Comments
Population infected (%) (Johns Hopkins University, 2020; Centers for Disease Control, 2020; Center for Health Protection, 2020)	<ul style="list-style-type: none"> 5480 cases to date, 0.07 % of HK population. Median age: 43 years. 	<ul style="list-style-type: none"> Global: 55 million cases, 0.7 % of global population and increasing. 	<ul style="list-style-type: none"> Early quarantine measures, personal distancing, mask-wearing and personal hygiene, vigilant contact tracing to reduce the at risk population from getting infected in Hong Kong.
Mortality (Johns Hopkins University, 2020; Cowling et al., 2020; Center for Health Protection, 2020)	<ul style="list-style-type: none"> Mortality 2% (108 deaths/5480 cases) 	<ul style="list-style-type: none"> Global: ~2.4 % (1.3 million deaths/55 million cases) US: 2.2 % (248,707 deaths/11.3 million cases) UK: 3.7 % (52839 deaths/1.4 million cases) 	<ul style="list-style-type: none"> High proportion of paediatric cases in Hong Kong. Most are teenage returning students. Nearly all asymptomatic.
Paediatric (Centers for Disease Control, 2020; Centers for Disease Control and Prevention, 2020b)	<ul style="list-style-type: none"> Approximately 9% (≤ 18 years old) of confirmed case No mortality, one PICU case. One KDSS or PIMS case. 	<ul style="list-style-type: none"> USA (< 18 years): ~7.7 % (644,364/8.3 million cases), Mortality 0.02 % (117 deaths/644364 cases). 	<ul style="list-style-type: none"> Early quarantine and limitation of hospital visitation is useful but psychosocial supports of elderly people important. Hong Kong experiences infectious disease outbreaks such as SARS and airport measles from time to time, and has world renowned experts to monitor public health policy. All COVID-19 patients are managed in the public hospitals and all non-COVID elective services are sacrificed in those hospitals.
Geriatric	<ul style="list-style-type: none"> No nursing home outbreak before June 2020. 	<ul style="list-style-type: none"> High mortality in nursing home outbreaks in western nations. 	<ul style="list-style-type: none"> Wearing mask and personal hygiene rituals not well observed in many western nations.
Hospital outbreaks (Wang et al., 2020; The Lancet, 2020; Malik et al., 2020)	<ul style="list-style-type: none"> No healthcare related transmission until June 2020. One healthcare worker infected during transport of a patient despite personal protective equipment. 	<ul style="list-style-type: none"> Hospital-related transmission was reported to be suspected in 56 patients (41 %) in a single-center case series of 138 patients (Wang et al., 2020). High transmission among healthcare workers (Malik et al., 2020). 	
Social venues of outbreaks in the community (Cowling et al., 2020)	<ul style="list-style-type: none"> Outbreak clusters involving karaokes, gymnastics, mini-temples in buildings, hotpot restaurants. 	<ul style="list-style-type: none"> Large outbreaks in social gatherings, e.g. a Jewish funeral, Korean church. Prime minister, royals, and officials affected overseas. 	
Cruise boats	<ul style="list-style-type: none"> One such outbreak but no fatality. 	<ul style="list-style-type: none"> Major cruising ship outbreaks in Japan and in the US. 	<ul style="list-style-type: none"> Good public health quarantine measures in Hong Kong to minimise mortality and morbidity Pet-to-human transfer considered not likely, but COVID remains a possible zoonotic disease initially from consumption of wide animal meat. Might raise animal right issues if pets are quarantined.
Veterinary (World Organisation For Animal Health, 2020; The Government of the Hong Kong Special Administrative Region, 2020)	<ul style="list-style-type: none"> 2 dogs and 8 cats tested positive for SARS-CoV-2. One death of a recovered dog after the isolation. 	<ul style="list-style-type: none"> Globally, 4 cats, 2 minks, 1 tiger and 1 lion tested positive for SARS-CoV-2. 	

seafood in Beijing's wholesale food market to be severely contaminated with SARS-CoV-2 and suspected that the area's low temperature and high humidity may have been contributing factors (Kim, 2020; South China Morning Post, 2020a). A preliminary report linked the outbreak to the Xinfadi food market, which include warehouses and trading halls (Wang et al., 2020). The Xinfadi market is located in the south-western Beijing district, Fengtai. With a size of 1.12 square kilometres (equivalent to 157 football fields), the Xinfadi market is Beijing's largest wholesale market, supplying about 80 per cent of the city's fresh produce. It is reportedly Asia's largest wholesale market for agricultural products. The outbreak infected more than 100 people and raised fears of wider contagion in China. Among the patients who worked at the Xinfadi market, most were found at one of the seafood and aquatic product stalls, followed by the beef and mutton sections. China halted imports from European salmon suppliers amid fears that they may be linked to the Beijing outbreak. Recently, Chinese customs identified six COVID-19 positive samples from the container and packaging of imported frozen shrimps, leading to suspension of imports from three Ecuador companies (South China Morning Post, 2020b).

Finally, a number of local transmissions and outbreaks have been linked to food and restaurants (U.S. Food and Drug, 2020). Although there is no solid evidence to date that SARS-CoV-2 can be transmitted by food or food packaging, it is still important for the public and food production industries to remain vigilant when handling food and practice extra hygiene measures during this extraordinary time.

Regardless of the COVID-19 circumstances, all members of the population should practice long-standing food safety measures including: hand hygiene before food-handling, washing fruits and vegetables with clean water before consumption, washing all packaging immediately when it enters the household, remove outer packaging and transfer packaged food to cleaned containers before storage, store raw meat separately from other food, and cook food at high temperatures (World Health Organization, 2020; Food Packaging Forum Foundation, 2020).

As of April 27, 2020, the USA has identified various COVID-19 hotspots related to meat and poultry processing facilities, where there have been 4913 confirmed cases and 20 deaths among 130,000 workers (Dyal et al., 2020). A separate analysis has shown more than 32,700 COVID-19 cases and 128 worker deaths at meatpacking facilities in the USA (Gannett, 2020). Although the food processing industry is an essential part of the economy that needs to remain open during lockdowns, operators in the industry should be vigilant of the potential risks of workplace transmissions.

4. Animals as vectors: From Leviticus to COVID-19

Infectious diseases continue to be a threat to humanity, and epidemics of zoonosis have been with us since the dawn of human history (Hon and Leung, 2020; Hon et al., 2020b; Rahman et al., 2020). The pandemic has generated many questions and issues to be dealt with by health agencies. Respiratory diseases are clearly spread by droplets and airborne transmission. The general principles of social distancing, wearing masks, personal hygiene and quarantine have stood the test of time. Epidemics have occurred throughout the history of mankind. To gain insight from history, we compared similarities and differences between Jewish practices over 3500 years ago in Biblical time and modern day public health practice. The book of Levitus (Torah – Hebrew Bible) is cited in Parts 1 and 2 below

4.1. Do not touch animal carcass without personal protective equipment

According to Leviticus 11:27–28: And whatever goes on its paws, among all kinds of animals that go on all fours, those are unclean to you. Whoever touches any such carcass shall be unclean until evening. Whoever carries any such carcass shall wash his clothes and be unclean until evening. It is unclean to you.

The vector of the 2003 SARS-CoV-1 epidemic was thought to be linked with the civet cat and subsequently the virus was also found in fruit bats (Hui et al., 2014; Cheng et al., 2007). These wild animals are considered as delicacies and consumed by some locals. Camels and bats have been incriminated as the possible vectors for the 2012 MERS-CoV epidemic (Zumla et al., 2015). The current 2020 SARS-CoV-2 pandemic is believed to stem from a local seafood market that also sold wild animals for consumption, though no definitive single animal has been identified as the cause.

Animals have also been the likely zoonotic source for other epidemics, including chimpanzees as 'bush' meat for the emergence of HIV and Ebola, wild birds and poultry for avian influenza, and pigs for the 2009 swine influenza A/H1N1 pandemic (American Veterinary Medical Association, 2020; Woolhouse et al., 2014; Alexanders and Brown, 2000).

Although there is no current evidence that definitively links the cause of this pandemic to close contact with an animal, this is likely (Turcios-Casco and Cazzolla Gatti, 2020; Gudadappanavar and Benni, 2020). The main concern over these wet markets is that there is close proximity of many species of live animals to humans. Although there are no proven links between the animal origins of the current pandemic and the food preferences of southern China some cuisines will naturally drive the demand for more unusual animals like the civets and bats.

4.2. Do not eat certain wild animals

Leviticus 11:13–19: And these you shall regard as an abomination among the birds; they shall not be eaten, they are an abomination: the eagle, the vulture, the buzzard, the kite, and the falcon after its kind; every raven after its kind, the ostrich, the short-eared owl, the sea gull, and the hawk after its kind; the little owl, the fisher owl, and the screech owl; the white owl, the jackdaw, and the carrion vulture; the stork, the heron after its kind, the hoopoe, and the bat.

As aforementioned, wild animals such as civets and bats have been considered as delicacies and consumed by some Chinese people. Sales of wild animal meat for consumption must be prohibited or at least regulated by public health authorities. Horseshoe bats are the natural reservoir for SARS-CoV-like virus with civets being the amplifying host. This highlights the importance of wildlife and biosecurity in farms and wet markets, which can serve as the source and amplification centers for emerging infections (Cheng et al., 2007).

In modern day, farmed animals have also been implicated in epidemic infectious diseases. Good examples include the bovine spongiform encephalopathy (also known as BSE or mad cow disease) outbreak in the UK in the 1980s and 1990s, and the haemolytic uraemic syndrome epidemic associated with undercooked burger patties in the US in 1982–2002 (Kumagai et al., 2019; Rangel et al., 2005).

4.3. Quarantine for 14 days

Leviticus 13:5–6: And the priest shall examine him on the seventh day; and indeed if the sore appears to be as it was, and the sore has not spread on the skin, then the priest shall isolate him another seven days. Then the priest shall examine him again on the seventh day; and indeed if the sore has faded, and the sore has not spread on the skin, then the priest shall pronounce him clean; it is only a scab, and he shall wash his clothes and be clean.

In the 2003 SARS epidemic, it was mandatory to quarantine patients for 21 days. The duration for quarantine and isolation for the current SAR-CoV-2 is 14 days. The quarantine or isolation period is usually chosen to be 2–3 times the maximum of the average incubation period, so about 7 days for SARS-CoV-1, and 5 days for SARS-CoV-2. Thus, quarantine durations are disease-specific and based on the incubation periods.

In this quote, Leviticus seemed to refer more to the course of an established disease than the incubation period of a developing disease.

Research on zoonotic diseases often focus on the transmission of diseases from animals to humans. However, an increasing number of reports indicate that humans are transmitting pathogens to animals (Messinger et al., 2014; Rahman et al., 2020; Bosco-Lauth et al., 2020). Examples include methicillin-resistant *Staphylococcus aureus*, influenza A virus, *Cryptosporidium parvum*, and *Ascaris lumbricoides*. Reverse zoonoses transmission has occurred in nearly every continent indicating a worldwide disease threat (Messinger et al., 2014).

Although pet-to-human transfer of SARS-CoV-2 has been considered unlikely, this remains a possibility (American Veterinary Medical Association, 2020). To date, 2 dogs and 8 cats have been tested positive for SARS-CoV-2, with the death of a recovered dog after the 14-day quarantine in Hong Kong. Globally, SARS-CoV-2 has been detected in dogs, cats, minks, tiger and lion (American Veterinary Medical Association, 2020; Centers for Disease Control and Prevention, 2020a).

4.4. Proper disposal of contaminated clothing

Leviticus 13:52: He shall therefore burn that garment in which is the plague, whether warp or woof, in wool or in linen, or anything of leather, for it is an active leprosy; the garment shall be burned in the fire.

Potentially contaminated surfaces, clothes and fomites need to be disinfected on a regular basis. Disinfection with diluted household bleach solution is one simple method of doing this. Donning and doffing of personal protective equipment such as gowns and masks should be meticulously adhered to, with disinfection or sterilization of contaminated clothing (Pericàs et al., 2020).

5. Conclusions

From a modern scientific post-germ-theory perspective, these ancient Biblical practices might seem akin to non-scientific-verified practices. The current public health management of COVID-19 requires quarantine and isolation of patients and close contacts, which bears resemblance to ancient practices in the Jewish scripture more than 3500 years ago. These public health measures together with the development and availability of effective vaccines and antimicrobial therapeutics provide effective tools to control infectious diseases, epidemics and pandemics.

A disease vector is any agent that carries and transmits an infectious pathogen into another host. Agents regarded as vectors can be animals, insects, parasites or even microbes. The World Health Organization (WHO) advocates an "Integrated Vector Management (IVM)" approach to dealing with vector-borne diseases, which examines the links between health and the environment, attempting to optimize the benefits to both. It is likely that rapid changes in land use, trade globalization, and socio-economic instability are all factors contributing to a surge in zoonotic disease across the world (Weiss and McMichael, 2004; McMichael, 2004).

Authors' contributions

KLH conceived of the writing and is the principal author. All authors critically reviewed the manuscript and approved the final manuscript.

Declaration of Competing Interest

The authors report no declarations of interest.

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