

The Healthy Crew, Clean Vessel, and Set Departure Date Triad: Successful Control of Outbreaks of COVID-19 On Board Four Cargo Vessels

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Abbreviations:

AUSMAT-WA: Australian Medical Assistance Team – Western Australia
CCTV: closed-circuit television
COVID-19: Coronavirus Disease 2019
EC: essential crew
IPC: infection protection and control
MSM: Minimum Safe Manning
n-EC: non-essential crew
PPE: personal protective equipment
Q: quarantine

Abstract

Background: A variety of infectious diseases can cause outbreaks on board vessels, with both health and economic effects. Internationally, Coronavirus Disease 2019 (COVID-19) outbreaks have occurred on numerous cruise and cargo vessels and the containment measures, travel restrictions, and border closures continue to make it increasingly difficult for ship operators world-wide to be granted pratique, effect crew changes, and conduct trade. An effective outbreak management strategy is essential to achieve the outcome triad – healthy crew, clean vessel, and set departure date – while maintaining the safety of the on-shore workers and broader community and minimizing disruption to trade. This report describes the principles of COVID-19 outbreak responses on four cargo vessels, including the successful use of one vessel as a quarantine facility.

Methods: Established principles of management and the experiences of COVID-19 outbreaks on cruise ships elsewhere informed a health-lead, multi-agency, strict 14-day quarantine (Q) regime based on: population density reduction on board; crew segregation; vessel cleaning and sanitation; infection risk zones, access, and control measures; health monitoring; case identification and management; food preparation and delivery; waste management control; communication; and welfare and security.

Findings: Sixty-five crew were diagnosed with Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) infection (range 2–25; attack rate 10%–81%; 15 asymptomatic). No deaths were recorded, and only one crew was hospitalized for COVID-19-related symptoms but did not require intensive care support. Catering crew were among the cases on three vessels. All non-essential crew (n-EC) and most of the cases were disembarked. During the vessel's Q period, no further cases were diagnosed on board, and no crew became symptomatic after completion of Q. The outbreak response duration was 15–17 days from initial decision.

No serious health issues were reported, no response staff became infected, and only two Q protocol breaches occurred among crew.

Interpretation: Despite increasing risk of outbreaks on cargo vessels, maritime trade and crew exchanges must continue. The potential consequences of COVID-19 outbreaks to human life and to trade necessitate a balanced response. The principles described can offer health, financial, operational, and safety advantages.

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rRT-PCR: real-time reverse transcription polymerase chain reaction

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2

WA: Western Australia

WHO: World Health Organization

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Introduction

Similar to cruise ships, cargo vessels favor the rapid spread of infectious diseases due to a high population density, direct contact between crew, and common food and water preparation and delivery.^{1,2} Most infectious diseases causing outbreaks on ships affect the respiratory and the gastro-intestinal systems,³ and a variety of pathogens have been implicated.^{1,4-25}

Western Australia (WA) records more than 10,000 yearly cargo vessel movements and is home to the world's largest bulk export port.²⁶ Infection diseases on board vessels can have significant health^{1,3,27,28} and economic effects.²⁹ Thus, all vessels need to comply with international sanitation legislation³⁰⁻³⁸ which informs minimum standards to "prevent, protect against, control, and provide a public health response to the international spread of disease in ways which are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade."³⁴

Many outbreaks have been identified on board merchant vessels³⁹⁻⁴¹ following the World Health Organization (WHO; Geneva, Switzerland) Coronavirus Disease 2019 (COVID-19) pandemic declaration.⁴² While quarantine (Q) – "the restriction of activities of or the separation of persons who are not ill but who may have been exposed to an infectious agent or disease"⁴³ – has been a cornerstone for controlling infectious disease outbreaks for centuries,⁴⁴ additional measures such as isolation and sanitation on board vessels are mandated under the International Health Regulations.^{8,17,20,34,40,45-52} Quarantining decreased the transmission of Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) during vessels' outbreaks,^{40,45} but it did not completely control the event, with further cases occurring after release from Q.^{40,46,53-55}

The containment measures, travel restrictions, and border closures² continue to make it increasingly difficult for ship operators world-wide to be granted *pratique* – "permission for a ship to enter a port, embark or disembark, discharge or load cargo or stores,"^{34,56} – conduct trade, and change crew.^{57,58}

An effective outbreak management strategy is essential to achieve the outcome triad of healthy crew, clean vessel, and set departure date while maintaining the safety of the on-shore workers and larger community, and minimizing disruption to trade.

This report describes the principles of COVID-19 outbreak responses on four cargo ships: two bulk- (Patricia Oldendorff and Key Integrity) and two livestock transport vessels (Al Kuwait, Al Messilah), including the successful use of one of the vessels as a Q facility.

Methods

Command and Coordination

The Western Australian Government has legislated responsibility for human biosecurity for international maritime arrivals and took the lead role in a multi-agency response to the outbreaks, tasking the Australian Medical Assistance Team – Western Australia (AUSMAT-WA)⁵⁹ to coordinate the operational aspects of managing the outbreaks. The AUSMAT-WA team worked closely with state agencies involved in biosecurity and border control, the state health department, law enforcement agency, and the port authorities.

Operational Response Foundation Principles

The response was based on 12 principles (Table 1) involving adopting and validating risks, hazards, and control measures; regular

1. Vessel safety and security
2. Safety of shore-based workers and wider community
3. Vessel access safety and control
4. Reduction of the population density on board
5. Cleaning and sanitation
6. Quarantine zones and isolation
7. Infection control and personal protective equipment requirements
8. Control of food preparation and delivery
9. Physical and mental health monitoring, SARS-CoV-2 testing, and welfare
10. Monitoring of quarantine
11. Linen and waste management
12. End of quarantine clearance documentation

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Table 1. Foundation Principles for the COVID-19 Outbreak Response On Board Commercial Vessels

analysis and reporting; effective and timely remedial actions; verification procedures; and continual on-board monitoring of the Q process.

1. *Vessel Safety and Security*—The safety and security of the vessel and crew during the Q process is paramount and the response plan was adapted to the vessel location, type, and layout; local geographical and nautical circumstances; and other independent operational limitations (vicinity to other vessels and port operations).
2. *Safety of Shore-Based Workers and Wider Community*—Only AUSMAT-WA staff and supervised external contractors could board the vessel or enter established Q zones, using strict infection protection and control (IPC) measures.
3. *Vessel Access and Control*—A strict access protocol was determined by the position of the vessel (alongside or at anchor) and in compliance with border security requirements.
4. *Reduction of the Population Density On Board*—The vital functions of the vessel need to be maintained at all times and the Minimum Safe Manning (MSM) certificate^{60,61} provides the legal requirements for each vessel while underway. Based on the MSM, vessel Command, in consultation with the Operator, Flag State, Port Authority, and the Australian Maritime Safety Authority (Braddon, Australian Capital Territory), split the crew into two groups: (1) essential crew (EC), whose role is to maintain the safety (fire-fighting capacity, mooring lines) and vital functions (power supply and remote or direct systems monitoring) of the ship during the Q period; and (2) non-essential crew (n-EC). Before the start of Q, all known SARS-CoV-2 positive cases were disembarked to a secure hotel; however, it is recognized that, if in doing so the EC is depleted beyond safety levels, this might not be achieved.
5. *Cleaning and Sanitation*—Although SARS-CoV-2 virus is highly contagious,^{62,63} it was not necessary, nor possible, to clean the entire vessel before or during Q. A hospital-grade^{64,65} environmental disinfection of the accommodation structure was begun as soon as possible, all within 24 hours, and was conducted by quality assured professionals. The aim was to reduce the viral load⁶³ on board and to create decontaminated access areas that were used by AUSMAT-WA and the cleaners (rest area). Contamination of the communal

Cohort	Location/Activity	PPE Requirement
Essential Crew	Own Cabin	Not required
	Own Cabin Balcony	Surgical mask
	Food Collection/Cabin Waste Removal	Surgical mask, gloves, distancing of 2m
	Routine Duties in Normal Working Zones	Surgical mask, gloves, and distancing of 2m unless impossible due to the nature of the work carried out
	Emergency Duties Outside Normal Working Zones	Coverall suit, surgical mask, gloves, distancing of 2m unless impossible due to the nature of the work carried out
Health Team	Face-to-Face Cabin Visit	N95 mask, protective eyewear, impervious gown and gloves, distancing of 2m unless impossible due to the nature of the work carried out
	Food Delivery	
	Waste Removal	
External Contractors	CCTV Installation after Vessel Environmental Clean	Surgical mask, gloves, distancing of 2m

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Table 2. Personal Protective Equipment Requirements in the Control Zones
Abbreviations: PPE, personal protective equipment; CCTV, closed-circuit television.

areas (deck corridors, bridge, engine room office) was controlled during Q by performing a daily clean of frequently touched surfaces and floors. The cleaning equipment used was disinfected at the end of each day and, when possible, left on board in a cleaned area. All equipment was cleaned prior to return to shore at the end of the Q process.

6. *Quarantine Zones and Isolation*—The accommodation space has a “tower with central stairwell” design on bulk and livestock carriers. During Q, some of the communal areas (central stairwell, mess room, galley, pantry, food stores, laundry) were restricted unless in emergencies; others form the work (bridge, engine room) and access areas (external staircases, corridors to cabins) which needed to remain always accessible. The work areas of the EC were cleaned to environmental standards, but were considered contaminated owing to on-going work traffic from potentially infected EC. Cabins vacated by the n-EC were locked and not disinfected during the Q.
7. *Infection Control and Personal Protective Equipment Requirements*—The EC were accommodated in their own, individual cabins, allowed to attend their designated workplaces, and to respond to any vessel emergency. All vacated cabin doors were marked to facilitate identification of crew and for emergency evacuation.

Donning and doffing stations were set up on board (access point to accommodation structure) and/or on shore (gangway). Disinfection stations were set up on board at strategic locations. Each crew was provided with a cabin cleaning kit with enough supplies to last the duration of the Q and instructed to clean their own cabins at least twice daily. Within the contaminated areas, different levels of personal protective equipment (PPE) requirements were mandated (Table 2).

All external contractors were trained in PPE donning and doffing procedures, and compliance was monitored by AUSMAT-WA at the entry and exit points.

8. *Control of Food Preparation and Delivery*—Where available in the cabin, refrigerators were stocked with several days' supply of bottled water, long-life food and beverage items prior to Q commencement. The on-board kitchen and catering facilities were not used to limit potential fomite spread. External caterers were engaged to prepare and deliver dock-side culturally appropriate meals not dissimilar to those

normally available on board. The AUSMAT-WA teams delivered the meals on board either directly (no-touch process) or using the vessel's crane. Logistical delivery burden was managed by a once-a-day only food drop (one hot and two cold meals).

9. *Physical and Mental Health Monitoring, SARS-CoV-2 Testing, and Welfare*—Typically, commercial vessels do not have on-board medical facilities.² After commencement of Q, a health questionnaire based on the same guidelines⁶⁶ was used for the daily screening of EC using the vessel fixed phone lines, smart mobile phones (video capability), or face-to-face interviews. Any screening failure prompted escalation to a face-to-face interview and temperature measurement. For vessels at anchor, all EC were provided with, and trained to use, a smart mobile phone, a thermometer, and a finger pulse-oximeter.

Any negative crew member with symptoms, either self-reported or elicited during health screening, had oro-pharyngeal and bilateral deep nasal swab samples collected for SARS-CoV-2 testing (combined in-house real-time reverse transcription polymerase chain reaction [rRT-PCR] assay directed at envelope and spike protein gene targets). Additional rRT-PCR testing was done on asymptomatic EC at various intervals to ensure the rapid detection of possible new cases which would threaten the agreed EC structure. The swabs were placed in viral transport medium and stored at 4°C–8°C prior to testing at an accredited⁶⁷ laboratory. Additional serological testing was carried out for targeted crew if EC numbers were under threat to be further depleted and the detection of historical cases. Case definitions (Table 3) reflected the Australian public health guidelines for COVID-19.⁶⁶

The official language on-board vessels is English.^{68,69} During the response to the outbreak on the cruise ship MV Artania,⁷⁰ it was found that the crew had a reasonably good command of the language. However, this was not observed during the response on cargo vessels, and this has become manifest during the initial contact tracing interviews. The health questionnaire was translated in the preferred language of the individual, and interpreter services were readily available. The AUSMAT-WA teams also received, attended, and assessed health-related calls from crew. The initial response was by telephone and escalated to a cabin visit or engaging the on-shore WA health emergency resources, following pre-established contingency plans.

		VESSEL			
		ALK	PO	ALM	KI
Departure Date from Last Overseas Port and Crew Change		7 May 20	5 Sept 20	2 Oct 20	6 Oct 20
Arrival Date in WA Port		22 May 20	16 Sept 20	14 Oct 20	17 Oct 20
Vessel Quarantine	Start	30 May 20	27 Sept 20	22 Oct 20	22 Oct 20
	End	13 Jun 20	10 Oct 20	5 Nov 20	5 Nov 20
Earliest Symptoms in Crew		10 May 20	12 Sept 20	5 Oct 20	5 Oct 20
Departure Date from WA Port		19 Jun 20	11 Oct 20	9 Nov 20	5 Nov 20
Crew ^a	Total On Board	48	21	55	20
	Age Range, mean (Q ₂₅ , Q ₇₅ , IQR)	26 - 65, 44.6 (36, 52, 16)	23 - 58, 34.6 (25, 41, 16)	19 - 63, 41.6 (28, 53, 25)	24 - 59, 39.5 (30, 48, 17)
	MSM ^c Crew	21	13	21	13
	Disembarked (Cases and n-EC)	38	12	38	8
	EC On Board during Q	10	9	14	12
rRT-PCR	Total	21	17	25	2
Confirmed Cases ^b	Age Range, mean (Q ₂₅ , Q ₇₅ , IQR)	31 - 60, 43.6 (36, 49, 13)	23 - 58, 34.1 (25, 40, 15)	19 - 63, 39.6 (27, 52, 25)	31 - 41, 36 (33, 38, 5)
	Asymptomatic Cases (%)	0	35.3 (6/17)	16.0 (4/25)	0
	Hospital Admissions	Total	2	0	1
	COVID-19-Related	1	0	0	0
	Intensive Care	0	0	0	0
	Death	0	0	0	0
Attack Rate	Before Q Start (%)	43.7 (21/48)	81.0 (17/21)	45.4 (25/55)	10.0 (2/20)
	After Q Start (%) (EC on Vessel)	0	0	0	0
	After Q Start (%) (n-EC in Hotel Q)	0	0	0	0

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Table 3. Summary of Vessel Movements, Quarantine Periods, and SARS-CoV-2 Infections

Abbreviations: ALK, MV Al Kuwait; PO, MV Patricia Oldendorff; ALM, MV Al Messilah; KI, MV Key Integrity; WA, Western Australia; n-EC, non-essential crew; MSM, Minimum Safe Manning; EC, essential crew; Q, quarantine; Q₂₅, 25th quartile; Q₇₅, 75th quartile; IQR, interquartile range.

^a Crew includes all officers and ratings.

^b Confirmed case is defined as a positive reverse transcription polymerase chain reaction test on an oro-pharyngeal and bilateral deep nasal specimen.

^c MSM = the level of manning that will ensure that a specific ship is sufficiently, effectively, and efficiently manned to provide: safety and security of the ship, safe navigation and operations at sea, safe operations in port, prevention of human injury or loss of life, the avoidance of damage to the marine environment and property, and the welfare and health of seafarers through the avoidance of fatigue.⁵⁷

Good communication was the main process to mitigate possible psychological stress and feelings of isolation and to improve compliance with the Q requirements. This included individual two-way and mass-SMS messaging, which kept the crew accurately informed; using the daily health checks as opportunities for high-quality contact time; acknowledging special events (half-way through Q period, birthdays, and religious days); daily “brain teaser” exercises; and local community and culturally-linked associations’ engagement and support.

10. *Monitoring of Quarantine*—A comprehensive brief detailing the Q process, obligations, and restrictions was communicated to the EC. To allow the review and inform the

remedial action of any potential breach, compliance was continuously monitored in communal areas by a temporary camera internal closed-circuit television (CCTV) system installed on three vessels. Disembarkation of all positive cases from the fourth vessel was not possible, thus the EC on board was a mix of cases and close contacts; therefore, CCTV monitoring was deemed not providing significant additional value.

11. *Linen and Waste Management*—To minimize traffic, waste bags and two sets of bed linen were placed in each occupied cabin; however, contingencies for special circumstances were available. At the end of the Q, all laundry and linen were collected in plastic bags and hot-cleaned using the

commercial washing facilities on board.⁷¹ At the initial vessel clean, waste was removed from vacated cabins together with all perishable food from the messroom and galley. Judicious packaging of the food provided during Q produced minimal waste.

12. *End of Quarantine Clearance Documentation and Documents*—The Q clearance process followed evolving national guidelines.⁶⁶ Each crew received a Letter of Clearance of Quarantine detailing personal circumstances. The Master and Shipping Agent were provided with a document certifying that the vessel has been cleaned to the required specifications and was free of SARS-CoV-2.

Ethical Considerations

The data collection, analysis, storage, and reporting were conducted in line with the WHO Ethical Standards for Research During Public Health Emergencies (COVID-19), the WHO Guidance for Managing Ethical Issues in Infectious Diseases Outbreaks, and the WHO Guidelines on Ethical Issues in Public Health Surveillance. Ethics approval was not required for this investigation, conducted as part of the public health response to outbreaks of COVID-19, a notifiable infectious disease under the Western Australia Public Health Act 2016. The release of data not already in the public domain has been granted by the WA Department of Health (Perth, Western Australia) Public Health Emergency Operations Centre Data Custodian.

Data Management and Analysis

The data were entered into a Microsoft Excel 2019 Ver. 2102 (Microsoft Corporation; Redmond, Washington USA) spreadsheet. Statistical analysis was limited to descriptive statistics.

Results

To maximize the number of non-infected crew available to sail the vessel at the end of Q, and to reduce the Q duration, each disembarked crew (n-EC and cases) was isolated in hotels (single room, with non-shared facilities). However, this was not possible on one vessel without severely compromising its MSM, thus essential duties were carried out by an EC consisting of cases and close contacts, not in strict isolation.

One outbreak involved 17 out of 21 crew (81%) and the disembarkation of all cases would have reduced the vessel manning to unsafe levels. In the absence of suitable replacement ratings, the nine EC left on board included seven infected crew, all under strict infection control directions. The two close contacts were disembarked prior to the vessel's departure and remained SARS-CoV-2 negative at the end of their 14-day quarantine in WA.

Overall, 65 crew (age range 19–63) were diagnosed with SARS-CoV-2 infection (15 asymptomatic). Three crew were hospitalized, only one for moderate COVID-19-related symptoms not requiring intensive care support, and no deaths were recorded. As described in other cruise vessel outbreaks,^{45,53} catering crew were among the cases found on three of the four vessels (Table 3). The epidemic curves of the outbreaks are presented in Figure 1, Figure 2, Figure 3, and Figure 4.

Before Q started, the attack rate varied between 10%–81% with no further infections recorded thereafter in close contacts. Public Health interviews determined that with one exception, all index cases diagnosed on arrival at WA Ports were not the first case on board.

Only three crew from the same vessel did not clear Q at 14 days and remained in WA after the vessel's departure. No serious mental

or physical health issues were reported, with the main complaints conveyed by crew in hotel Q being the lack of access to exercising and specific food requirements.

The period between overseas departure and first symptoms described amongst crew ranged from three to seven days; however, one case developed symptoms before overseas embarkation, yet tested negative (RT-PCR) on departure day and was allowed to board.

The MSM specifies the minimum crew required for a vessel underway, and this can be further reduced after discussions with the relevant parties if the vessel is alongside or at anchor.

Two IPC breaches were demonstrated by real-time CCTV monitoring (cabin door opened without wearing mask; crew entering a vacated cabin at the same time as the cleaners), allowing review and reinforcing educational messages for compliance.

The Q strategy employed allowed the shortest possible time to prepare and conduct the quarantine (average 15.5 days; range 15–17 days) from the decision to Q until release.

Post-Quarantine Period

All vessels were granted pratique at the end of their Q period, which allowed for loading and return to trade. Masters were supplied with IPC recommendations for their forward voyage.

Discussion

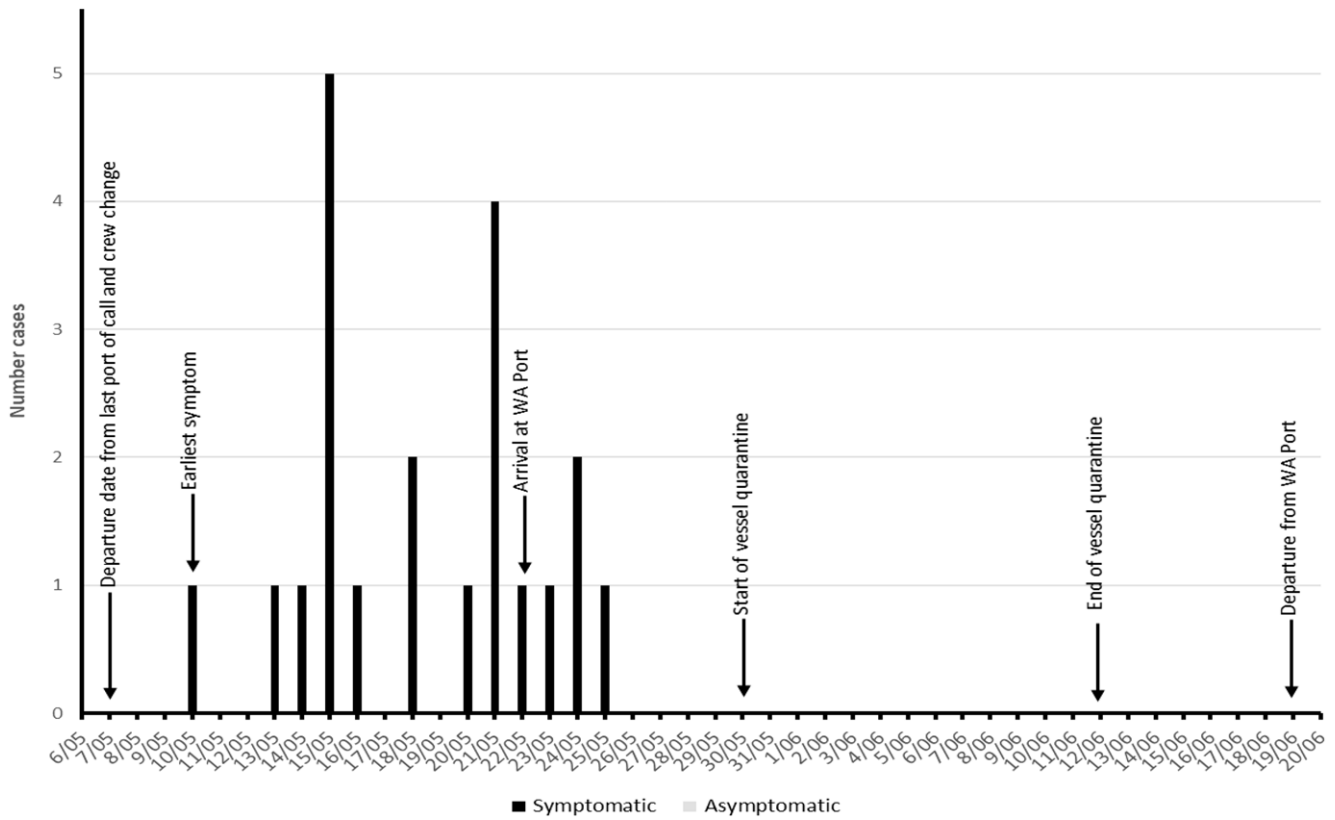
Merchant vessels (passenger and cargo) have processes in place to manage various types of infectious diseases outbreaks on board, underpinned by international regulations. While the WHO Interim Guidance² provides a high-level strategic direction for COVID-19 outbreaks, this should not detract from the need to design the complex processes to detect and respond to outbreaks while protecting the health of shore-based maritime workers and the larger community. The additional political scrutiny, community concerns, and trade implications^{72–76} compound the climate in which a swift outbreak management process is planned and conducted.

The knowledge and experience obtained from responding to outbreaks on cruise vessels informed the similarities and contrasts of the operational details of the outbreak management on the four cargo vessels.

Contrary to passengers on cruise ships,^{28,39,77} the prevalence of significant background health risk factors to amplify the severity of a SARS-CoV-2 infection (hypertension, obesity, diabetes⁷⁸) in a cargo vessel crew are low. Although the mortality and morbidity in COVID-19 is lower than those recorded in outbreaks of SARS and Middle East respiratory syndrome (MERS),^{78,79} quantifying the health threat for crew on vessels is in its infancy.

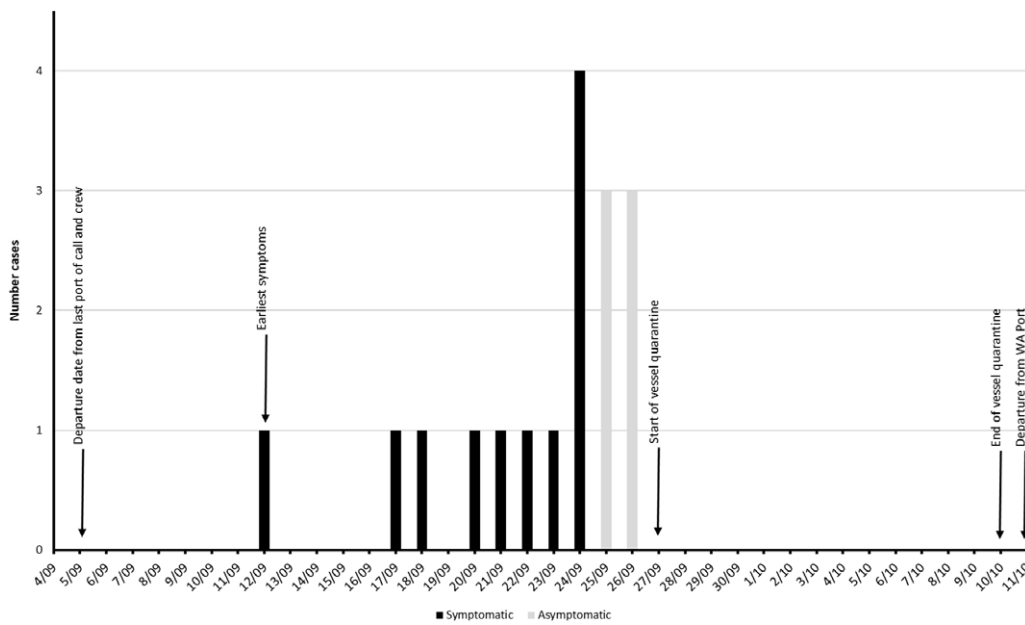
In many respects, commercial vessels present an apt environment to conduct a stringent Q process based on established IPC principles and consideration of the physical and psychological welfare of the crew,^{14,45,63,80–82} but subordinate to multi-agency agreements on minimum manning requirements for the vessel's vital functions, safety, and security obligations.

The ships were separated into areas reflecting their level of contamination and infection risk, and strict adherence to IPC was fundamental to the outbreak response process. Thorough daily cleaning maintained the status of these zones, and PPE requirements for each zone was rigidly enforced. Strict control of the food preparation (external caterer), and the no-contact food-drop system, essentially eliminated the direct contact between AUSMAT-WA staff and crew.



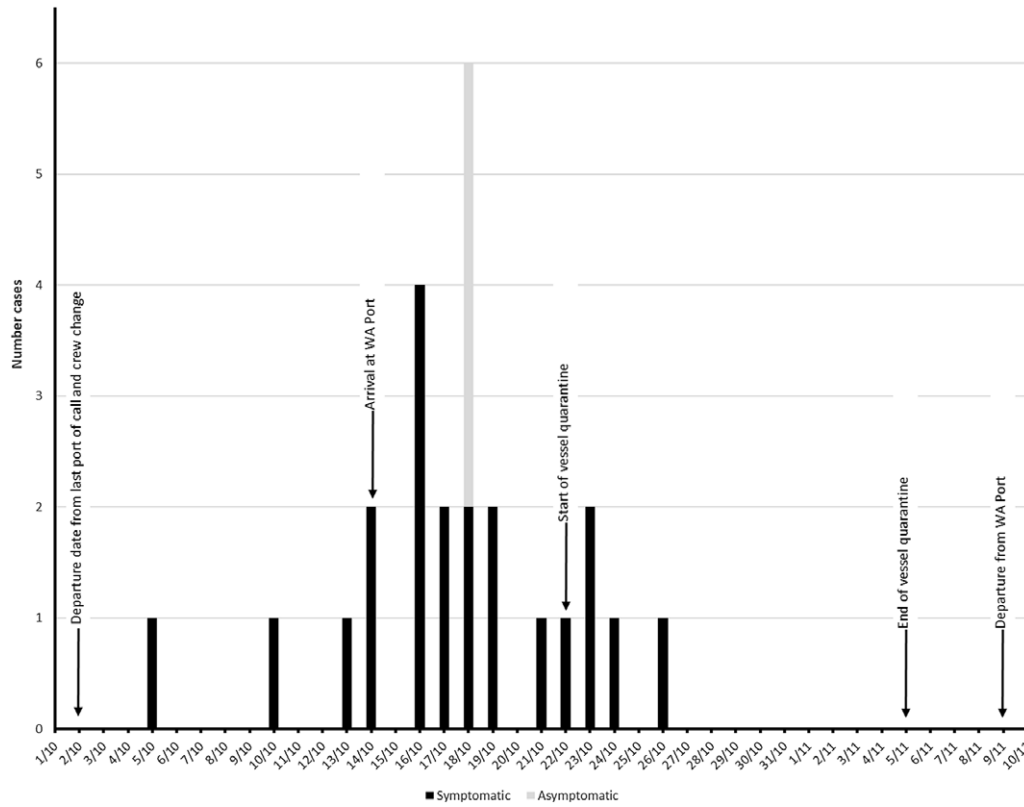
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Figure 1. Epidemic Curve of MV Al Kuwait Cases by Onset Date. Abbreviation: WA, Western Australia.



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Figure 2. Epidemic Curve of MV Patricia Oldendorff Cases by Optimal Date of Onset. Note: ODOO = onset date for symptomatic and the specimen date for asymptomatic cases. Abbreviation: WA, Western Australia.



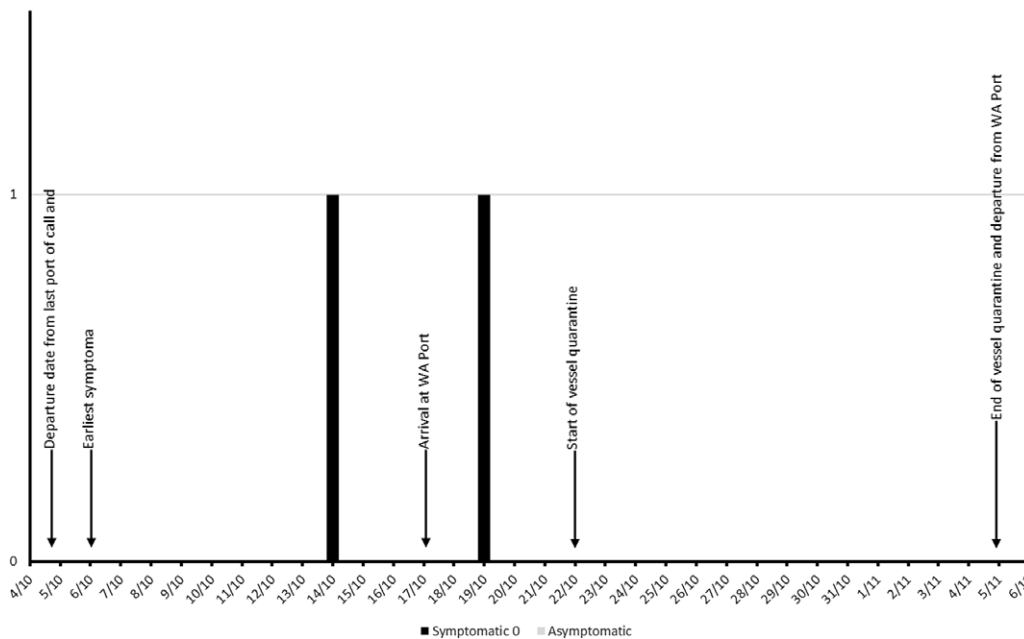
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Figure 3. Epidemic Curve of MV Al Messilah Cases by Optimal Date of Onset.

Note: ODOO = onset date for symptomatic and the specimen date for asymptomatic cases.

The cases illustrated between October 23–26, 2020 represent the onset of symptoms of four non-essential crew already in hotel quarantine, who tested positive on October 18, 2020 while asymptomatic. The asymptomatic cases illustrated on October 18 remained asymptomatic until their clearance from quarantine.

Abbreviation: WA, Western Australia.



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Figure 4. Epidemic Curve of MV Key Integrity Cases by Onset Date.

Abbreviation: WA, Western Australia.

Modern cargo vessels generally offer single-occupancy cabins with individual facilities and good communication options. Though EC were not permitted to share food and were always requested to observe IPC measures, CCTV could not monitor their entire working areas. The work routine was minimized to back-to-back watch duties, response to emergencies, and withholding non-essential maintenance work, thus reducing unnecessary traffic. Good communication and re-enforcing messages regarding strict adherence to the instituted IPC measures resulted in no further infection transmission among them. Where installed, CCTV cameras proved to be a strong deterrent to non-adherence to IPC measures and it ensured that any breaches were recognized, analyzed, and the infection risk managed.

The low level of SARS-CoV-2 activity in the Western Australian community at the time of the operations, coupled with symptom screening of all responders and the use of appropriate PPE, provided a high level of confidence that the responders were not a risk vector for infection themselves. In locations where SARS-CoV-2 activity would be higher, introduction of the virus on board by infected responders would need to be mitigated by regular symptom and temperature checks and/or SARS-CoV-2 testing.

Quarantine is challenging^{82,83} and potentially detrimental on physical and mental health, and this approach may have contributed to a lack of reported serious mental or physical issues. The length of Q can be minimized by strict adherence to its principles using various communication strategies and technologies: building rapport and support and reinforcing and encouraging compliance with the Q requirements during the daily health checks, acknowledgement of group or individual special events, and conveying accurate, consistent, and timely information.

All vessels being able to return to trading as planned and the absence of SARS-CoV-2 infections in any EC after the start of the vessel Q validated the processes' principles and execution.

Limitations

This paper has several limitations. Owing to evolving screening and testing National Guidelines, all asymptomatic n-EC were not tested as a condition of release, thus there is no certainty that during and at the end of Q, all re-embarked asymptomatic n-EC were not infected and infectious. Personal communications from the vessel Masters conveyed that none of the crew became symptomatic after

departure, and that those who disembarked at the destination harbors did not have to Q or be tested upon arrival. However, this information could not be formally confirmed. The combined theoretical risk of an undetected event⁸⁴ is 3.9% (CI 95%). In addition, on-going IPC measures after departure mitigated this small risk even further. The screening and testing protocols reflected Australian best practice at that time, and future vessel outbreaks would be managed accordingly.

Conclusion

Although the COVID-19 pandemic halted the international cruise ship industry, maritime trade continued. The risk of outbreaks on cargo vessels is likely to increase with the world-wide rising incidence of COVID-19, appearance of highly contagious novel strains, and the obligatory crew changes. The associated potential consequences to human life and to trade necessitate a balanced approach aimed at obtaining a departure date for a clean vessel manned by a healthy crew while maintaining the safety of the responders and broader community.

There are health, financial, operational, and safety advantages in using the outbreak management principles described, and the feasibility has been successfully demonstrated on four vessels.

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