

Delusions of Certainty: Commercial Vessel COVID-19 Risk Stratification

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Abbreviations:

COVID-19: coronavirus disease 2019
IMO: International Maritime Organization
rRT-PCR: real-time reverse transcription polymerase chain reaction
SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2
T°: body temperature
WA: Western Australia
WHO: World Health Organization

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Abstract

Since the World Health Organization's (WHO's) pandemic declaration on March 11, 2020, coronavirus disease 2019 (COVID-19) outbreaks have occurred on numerous maritime 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, conduct trade, and conduct crew changes.

Knowledge of Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) circulating on-board a ship prior to its arrival has significant implications for the protection of shore-based maritime workers (ie, pilots, stevedores, and surveyors), the broader community, and trade. A useful approach is a graded assessment of the public health risk. The Western Australia (WA) experience and associated observed pitfalls in implementing the prediction equation for the potential presence of SARS-CoV-2 on-board based on five COVID-19 outbreaks on commercial and cruise vessels during 2020 is described.

Despite best efforts, the qualitative and quantitative predictors of SARS-CoV-2 circulating on-board commercial vessels are failing to deliver the required certainty, and to date, the only accepted method of ascertaining the presence of SARS-CoV-2 remains the real-time reverse transcription polymerase chain reaction (rRT-PCR) testing reported by an accredited laboratory.

Based on legal or regulatory requirements, germane processes, underpinned by robust and auditable processes and procedures, must be put in place to inform the risk assessment of SARS-CoV-2 circulating on-board vessels.

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Introduction

A variety of infectious diseases can cause outbreaks on-board vessels, with significant health and economic effects.^{1–25} Since the World Health Organization (WHO; Geneva, Switzerland) coronavirus disease 2019 (COVID-19) pandemic declaration,²⁶ outbreaks have occurred on numerous 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,^{27,28} conduct trade,^{29–31} and effect crew changes.^{32–34}

Ports are vital to Australia's supply chain and account for 98% of the nation's trade through more than 34,000 yearly vessel movements (of which more than 12,000 are in Western Australia [WA] alone),³⁵ including through the world's largest bulk export port.³⁶

While Australia has a very low prevalence of COVID-19 infection in the community, and all international repatriating citizens are subject to mandatory quarantine, maritime traffic and ports remain a high-risk entry point for the infection.

Vessel crew's access to medical assistance in Australia is guaranteed under the International Convention on Maritime Search and Rescue³⁷ and the Maritime Labour Convention,³⁸ while the obligations to "provide appropriate medical treatment associated with any public health measures undertaken to prevent, protect against, control, and provide a public health response to the international spread of disease" are governed by the International Health Regulations.²⁸ On the other hand, the Emergency Management Act³⁹ allows for the issue of Maritime Crew Directions once they enter WA "for the purpose of preventing the importation of COVID-19 into WA and otherwise limiting the spread of COVID-19 in WA."

Until December 31, 2020, WA had confirmed 72 cases of COVID-19 in crew (all males, age range 19–65, mean age 39) on-board five commercial vessels, and 51 cases in crew on-board a cruise ship (45 males and six females, age range 26–61, mean age 40) including

one death (male, age 42). Consistent with previously reported data,⁴⁰ asymptomatic presentations were recorded in one-quarter of cases.

Commercial Vessel COVID-19 Risk Stratification

Determining the possibility of the presence of COVID-19 on-board commercial vessels prior to arrival has significant implications for the protection of shore-based maritime workers (ie, pilots, stevedores, and surveyors), the larger community, and trade.

A useful approach is provided by a graded assessment of the public health risk on-board. The risk assessment school of thought has evolved since the COVID-19 pandemic declaration,²⁶ and currently WA applies a combination of assumed independent predictors summarized below (with Severe Acute Respiratory Syndrome Coronavirus-2 [SARS-CoV-2]):

$$\text{Risk}_{\text{SARS-CoV-2 on vessel}} = [\text{Pre-embarkation (quarantine + SARS-CoV-2 Testing)}] \\ + [\text{Post-embarkation (14-days at sea + Screening COVID-19 symptoms} \\ + \text{Temperature monitoring + Non-COVID-19 Symptoms)}].$$

Here, the WA experience is presented along with associated observed pitfalls in implementing the prediction equation for the potential presence of SARS-CoV-2 infection on-board commercial vessels based on five COVID-19 outbreaks on commercial and cruise vessels during 2020.

Pre-Embarkation Quarantine

With crew changes being the highest risk of infection introduction on-board, many ship companies⁴¹ followed the recommendations issued by the European Commission (Brussels, Belgium)⁴² and International Maritime Organization (IMO; London, United Kingdom)⁴³ and have developed and implemented measures (such as pre-embarkation quarantine and SARS-CoV-2 testing) to prevent and mitigate the risk of transporting and spreading COVID-19 on-board vessels.

Quarantine – “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”⁴⁴ – has been a cornerstone for controlling infectious disease outbreaks for centuries,⁴⁵ and it ensures the early detection of cases by monitoring for illness onset and isolating these from others until they are no longer infectious.⁴⁶ In modern times, the period of quarantine is normally set at the maximum incubation period of the disease of interest, and 14 days is the typical period for COVID-19 clearance.

For quarantine to be effective, the individual needs to be in strict isolation for the entire duration. The term is applied loosely in some countries where the individual is not isolated but shares the “quarantine” accommodation with other crew.⁴⁷ In the absence of a standardized and adequately monitored pre-embarkation quarantine in all relevant countries, there is little value to the process.

Pre-Embarkation SARS-CoV-2 Testing

Essentially, two types of tests are available, antigen or antibody testing, and only the former is endorsed by the WHO⁴⁸ and the International Maritime Health Association (Flanders, Belgium).⁴⁹ In Australia, only the real-time reverse transcription polymerase chain reaction (rRT-PCR) test, performed at an Australian accredited laboratory, is accepted as proof of SARS-CoV-2 infection status at the time of testing, while IgG and IgM serology is accepted as proof of past infection.

In principle, overseas pre-embarkation tests have a certain value; however, they are performed in a variety of locations and

laboratories, and by a variety of methods, which can add confidence uncertainty. For example, one symptomatic crew returned a negative rRT-PCR test and was permitted to embark, becoming the index case of the outbreak on-board one of the vessels arriving in WA.

The results of the tests performed in asymptomatic crew confer certainty limited to the time of testing and have no predictive value as the individual may become symptomatic and/or infectious over the following days. All asymptomatic crew were tested prior to boarding the five vessels in their home ports, and the average duration between departure and symptoms onset was five days.

With the severe international boarding and labor marked constraints pivoting around the production of a negative SARS-CoV-2 test result, a black market has emerged which provides such fake reports on-demand or the know-how to forge another person's negative result.⁵⁰⁻⁵²

Minimum 14-Day Voyage at Sea

Based on the current 14-day quarantine requirements implemented by many countries for entry clearance, this minimum period has also been applied to crew on vessels at sea. The assumption is that, if infection exists on-board, the cases would have declared themselves by the end of this prescribed period.

The presence of asymptomatic cases and the subsequent transmission of the infection within the 14-days at sea makes this assumption flawed. Modelling of epidemiological curves suggest that a minimum of 60 days is required for an unmitigated infection on-board to extinguish itself in a 40-strong crew (Personal Communication: Codreanu TA, Department of Health Western Australia, May 2020), thus the 14-day period at sea adds a false sense of security.

Screening for COVID-19 Symptoms during Voyage

In Australia, Masters and shipping agents are obligated to apply for Australian biosecurity clearance⁵³ through the Maritime Arrivals Reporting System⁵⁴ (MARS) no later than 12 hours prior to arrival, and to lodge subsequent reports if relevant circumstances on-board change. The reporting involves the collection of information (ie, dates and location of the recent ports of entry and crew change, country of origin, and time at sea) including human-health aspects on-board.

Reflecting the evolving clinical knowledge, the Traveler with Illness Checklist (TIC) has been continuously amended with specific questions to assist with the detection of Listed Human Diseases (LHD), including COVID-19.⁵⁵⁻⁵⁷

The data collection tool is designed to add value, but it is limited by: (1) the significant number of asymptomatic cases; (2) the individual's English language proficiency; and (3) conscious and unconscious cognitive bias factors.

To avoid miscommunication, under the Standards of Training, Certification, and Watchkeeping Regulations,⁵⁸ English (Seaspeak) was declared the official maritime language world-wide since 2001, and the International Convention for the Safety of Life at Sea – SOLAS⁵⁹ treaty compels its use on all vessels unless another language is practiced by all concerned, including on-board, ship-to-ship, and ship-to-shore communications. However, mariners' English language proficiency standards have never been formally established by the IMO, and substandard performance has been established as the root cause in significant maritime accidents even 10 years after its implementation.⁶⁰

The evolution of the maritime industry saw crew originating from a myriad of countries and language backgrounds, and today 80% of crew are not listing English as their first language,⁶¹ in contrast to the situation at the end of 1970s. While each individual on-board is deemed proficient in English, this may only relate to maritime terminology.

The largely untested assumption that the English wording and nuances used in health questionnaires are readily understood by crew is misguided. Phrases such as “fatigue,” “muscular ache,” and “abdominal upset”⁶² are not in the usual vernacular of many international seafarers. The WHO lists “fatigue/tiredness” as one of the three most common symptoms,⁶³ yet it could be easily argued that in the context of a working crew on-board commercial vessels, “fatigue/tiredness” is difficult to define and interpret.

Desirability bias was observed in answering some questions: the rate of subjectively reported symptoms increased significantly after the start of quarantine on one vessel (without subsequent objective validation by testing) after the crew noted the outcome to be disembarkation to a five-star hotel if symptoms were declared.

Even with the benefit of doubt regarding asymptomatic cases, answers can also be affected by conformity bias. In past experience, the individual may decide not to disclose symptoms for reasons ranging from stigma to fear of personal financial repercussions.

Body Temperature Monitoring during Voyage

The only objective element in the screening for COVID-19 disease on-board is body temperature (T°) measurement. Commercial vessels rarely have medical facilities or trained medical personnel on-board, thus T° is recorded with infrared thermometers which provide a quick response time and are easy to use without special training.

The interpretation of T° results is undermined, however, on three levels:^{62,64-66}

1. Not all COVID-19 cases develop abnormal T° (or, conversely, an abnormal T° can be caused by other illnesses);
2. The T° threshold varies by the country's COVID-19 screening guidelines; and
3. The thermometer itself is subject to accuracy and uncertainty of measurement performance.

Instrument-generated systematic errors in measurements (up to 0.25°C for a real $T^{\circ} \geq 37.5^{\circ}\text{C}$) could be corrected by calibrating each thermometer, or for some instruments, using polynomial or linear

calibration equations. Random errors could be corrected by increasing the number and frequency of the recordings. In other words, for a given target temperature threshold, the reading could represent a persistent under- or over-measurement of the individual's real temperature⁶⁶ and the possible mitigation strategies are not readily applicable on-board commercial vessels.

Non-COVID-19-Related Symptoms

The constellation of symptoms and signs with which COVID-19 patients present has continuously evolved and informed medical knowledge; yet at the same time, it has also thwarted the confidence in determining the possibility of the SARS-CoV-2 virus as the causative agent for the presenting clinical scenario. For example, the WHO lists temperature, cough, and fatigue as the three main symptoms of mild COVID-19 disease,⁶³ with anosmia and ageusia still considered less-frequent symptoms. In past experience, very few of the COVID-19 cases diagnosed on-board vessels have had abnormal temperature, cough, or fatigue, while on the other hand, post-hoc investigation showed SARS-CoV-2 infection in three cases which presented with cardiac arrest, non-specific abdominal pain, and non-specific acute nephrotic syndrome, respectively.

Conclusion

Despite best efforts, the qualitative and quantitative predictors of a possible COVID-19 case on-board a commercial vessel are failing to deliver the required certainty, and to date, the only accepted method of ascertaining the presence or absence of SARS-CoV-2 infection remains rRT-PCR testing reported by an accredited laboratory.

The prediction calculation is one layer of a deceptively international equation underpinning risk analysis.

Strengthening of the attributes which form the predictors would require a standardized, monitored, and auditable quarantine process, and a trustworthy, secure, and standardized rRT-PCR testing sequence (for example, before embarkation and at seven- and 11-14-days post-departure). A duration at sea shorter than 60 days is of little reassurance, and equally so is temperature monitoring with uncalibrated instruments and low-frequency sampling.

Based on legal or regulatory requirements, germane processes, underpinned by robust and auditable processes and procedures, must be put in place to inform the risk assessment of possible on-board SARS-CoV-2 infection.

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