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Methods and tools for biological risk assessment of naval vessels

① Context

The COVID-19 epidemic highlighted the **weaknesses** of civil and naval vessels to overcome the propagation of infectious diseases on board, which **impacts the availability of forces**.



French Carrier Charles De Gaulle Heading Home Amid Suspicion Of Covid-19
The French Navy (Marine Nationale) aircraft carrier and flag ship Charles de Gaulle is heading home early following suspicion of several Covid-19 cases among its crew members.

Naval News, 2020 ©

The French Aircraft Carrier Charles de Gaulle is an example, where **protective measures** were implemented to **limit the spread** of the COVID-19 virus.

② Introduction and objectives

- The spread of pathogens is considered failure by **common mode**.
 - The consequences of such spread of pathogens on board can be considerable like the **inability of naval vessels to carry out their missions**.
- ➔ It is essential to assess **preventive and protective solutions** that limit the presence and spread of pathogens on board.

Expected results of the thesis

- Model of the propagation of pathogen on board
- Model of crew habits and movement on board
- Simulation tools to assess the level of biological resilience of naval vessels

③ Method

- Definition of the concept of biological resilience
- Common characteristics of pathogens [1]
- Categorization of pathogens according to common characteristics and identification of pathogens of interest ➔ **Risk analysis approach**

$$\text{Risk assessment} = \text{Detectability} \times \text{Probability} \times \text{Gravity}$$

Detectability
Contagiousness
Impact on the capability of the crew

Risk analysis approach

④ Thesis progress

Concept of biological resilience

“The ability to prevent, detect and limit the effects of, and bounce back from, destabilizing events linked to pathogenic threats, with the aim of recovering functions as effectively as possible to a state as close as possible to the state prior to the disturbance.”

Common characteristics of pathogens

The definition of solutions requires a sufficient understanding of:

- **Dynamic of the disease:**
 - Incubation period
 - Reproduction of the infection: R_0 ; P :PFU; ID_{50} ...
- **Human-to-human transmission**
- **Type of pathogen:** (increasing importance from 4 to 1)
 1. Viruses
 2. Bacteria
 3. Fungi
 4. Parasites
- **Mode of transmission:** (increasing importance from 3 to 1)
 1. Airborne (aerosol)
 2. Direct contact (droplet)
 3. Indirect contact (vehicle-borne and vector borne)
- **Mode of propagation:**
 - By sneezing
 - By coughing
 - By breathing
 - Bodily secretions
 - Feces
- **Capability impact (virulence)**

Describe by the symptoms of the infection

Categorization of pathogens of interest

- Propagation and severity indicators
- Evaluation of the mode of transmission of the pathogen, its infectivity, and its impact on the crew health and capability through detectability, likelihood, and gravity criteria according to risk assessment method
- Comparison of our selection to existing lists: OMS, HCSP, ARNT-MIE, bioterrorism...

Disease	Characteristics	Symptoms	Risk assessment of pathogens				Symptoms assessment			Risk assessment	
			Dynamic of the disease		Human-to-human transmission	Type of pathogen	Mode of transmission	Contagiousness (propagation and transmission) (C)	Impact on the capability (I)		Symptoms quotation (Q)
			Incubation period	R_0 ; P :PFU; ID_{50} ...							
Disease_A	Symptom_a Symptom_b	$R = f(D,P,Q)$	
			Detectability (D)	Probability (P)		Probability	Gravity				

⑤ Roadmap

