POLITECNICO
MILANO 1863

SCUOLA DI INGEGNERIA INDUSTRIALE
E DELL'INFORMAZIONE

THESIS SUMMARY

Behaviour-Based Safety for the containment of SARS-CoV-2 infection in the manufacturing industry

MASTER'S THESIS IN PREVENTION AND SAFETY ENGINEERING IN THE PROCESS INDUSTRY

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ACADEMIC YEAR: 2021-2022

Introduction

Throughout history, humans have been involved in a considerable number of pandemics, almost all of which were caused by viruses of animal origin that, due to a species jump, mutated to become infectious for the human species as well. This was more frequent in environments where humans lived in close contact with other animals, and where hygienic conditions were of poor quality. With increasing globalisation and mass urbanisation, the spread of infectious diseases has accelerated exponentially, so that the effects of this transmission have not only impacted society from a health perspective, but every aspect of the human sphere. Obviously, the productive fabric is not immune to the pandemic effects.

The aim of this thesis is to investigate the main pandemic events from the beginning of the industrial revolution to the present day, with a particular focus on the COVID-19 pandemic, which still greatly influences global industrial activities, limiting both production and economic return, but above all exposing the human factor to a considerable health risk. A focus will be made on the situation of the Italian State, as the country that first applied containment measures, which are among the most stringent globally, and on the measures adopted to contain the COVID-19 contagion within the manufacturing industry. This will be followed by an analysis of the results of these measures in order to determine whether or not they have been successful in reducing

the infection rate. The use of a parametric scientific method based on the observation and evaluation of workers' behaviour, Behaviour-Based Safety, will be proposed, with the aim of determining whether this method is effective in preventing the transmission of SARS-CoV-2, and whether by studying the results obtained it is possible to take preventive measures in advance of an increase in contagion.

1. Pandemics in history

1.1. Cholera

Cholera is an acute disease of the gastrointestinal tract caused by the bacterium Vibrio cholerae, and has plagued the world with no fewer than seven pandemics, killing millions. The place most affected industrially was England, where cholera first struck in 1831. The pandemic was aided by the industrial revolution, through the consequent growth of social housing and urban slums. Because of the outbreak of the disease, which was followed by epidemics of influenza and typhus over the years, investigations began to be made into sanitation. In the case of cholera, the impact on the industrial world did not so much involve the conduct of business as the very foundations of the system. Cholera and the discoveries associated with it led to the development of the first sanitary precautions, such as the sanitisation of drinking water. The interest in hygiene measures as disease prevention led with the 11th Paris Conference (1903) to the establishment of the 'International Bureau of Hygiene', which would later evolve into the establishment of the WHO (World Health Organisation, 1948).

1.2. Spanish flu

The Spanish flu pandemic, which struck the world population in 1918-1919 in three waves, is considered one of the greatest health disasters, in terms of morbidity and mortality, to have plagued humanity in recent centuries. It infected an estimated one billion people, killing between 21 and 25 million. A further complication of the situation was that the pandemic broke out towards the end of the First World War. State governments enacted measures to try to contain the contagion: in major cases they closed haunts, adopted isolation and quarantine for the infected and suggested the use of masks. The masks they used were made of gauze, but this was too porous to prevent infection; moreover, it was rare that they were worn properly. These measures, however, spared the manufacturing industry: apart from rare cases in which the mayors of major cities (especially American ones, of which more data is available) ordered the closure of manufacturing activities for a few days or weeks, the rest of the companies continued their production. This was because of the Great War, for which the production of equipment, tents, resources even foodstuffs was essential and could not be interrupted. Even though there were no official closures, the companies experienced very high absenteeism and a considerable reduction in the workforce, which led to a worldwide reduction in production. There is no definite data available on contagions within manufacturing activities. It is speculated, however, that since they were more or less the only businesses forced to remain open due to the need for products (required by both the war industry and essential goods and services for the population), the transmission of the virus was widespread among the workers of these businesses, and consequently also their families.

1.3. Asian flu

Asian influenza, caused by the influenza A(H2N2) virus, occurred from 1956 to 1958. Deaths are estimated to have reached 1.1 million. There is not much documentation on the effects in the manufacturing industry due to the pandemic, only mentions that there was severe absenteeism in industry (up to 80% of staff), but that most activities continued to work normally. With regard to preventive measures, little use was made of non-pharmaceutical interventions, such as school closures, travel restrictions, bans on gatherings or quarantines. Quarantine, in particular, was considered inappropriate due to the mild nature of the symptoms and the high overall number of infections.

1.4. Hong Kong flu

The A(H3N2) virus pandemic took place between 1968 and 1969, and caused between 500,000 and 2 million deaths in two waves. The mild symptoms of the disease and the modest mortality rates meant that more costly non-pharmaceutical interventions, such as school closures or quarantine, were not necessary. Strong absenteeism on the part of workers and business slowdowns on the part of industry were also observed.

1.5. COVID-19

SARS-CoV-2 is a β-coronaviru that attacks the human respiratory system and is capable of developing the 2019 coronavirus disease, COVID-19. The WHO (World Health Organisation) has drawn up basic rules of hygiene to prevent contagion, which have then been implemented by each country, which has disseminated them in its own territory. These are aimed at preventing both direct and indirect contact with infected fluids.

The most valid tool, however, for mitigating symptoms and preventing the onset of serious forms of the disease is vaccination. Moreover, vaccinated individuals have a lower viral load than non-vaccinated individuals. This suggests that not only do vaccines have a beneficial effect in protecting individuals from severe disease, but they also have an important function in containing virus transmission.

The Covid-19 pandemic has so far caused more than 500 million infections and over 6 million deaths worldwide. There is a very high incidence of cases of infection in January and March 2022.

The pandemic has not only caused health disruptions, but also economic, social, psychological and environmental ones. Many activities have been forced to close due to restrictions put in place by the governments of several countries for a longer or shorter period of time, or to take on new ways of working in order to cope with the health emergency. It is precisely because of the emergency that the use of smartworking (teleworking) has become increasingly widespread where tasks permit, so as to ensure the necessary distance between workers and the continuation of work despite the various closures (lockdowns) imposed by the authorities. Not all companies, however, have the option of opting for this solution; it is therefore necessary to adopt suitable prevention measures to allow work to continue, and the adoption of a parametric method that allows the prediction of the transmission curve so that preventive action can be taken.

2. Measures adopted by the Italian State to deal with the Covid-19 health emergency in the workplace

Italy is considered as the reference country in the survey because the measures adopted by its government were among the first to be implemented and among the most stringent.
The Italian government, through various D.P.C.M. and D.L., issued provisions to contain contagion in industries. As the number of contagions increased, it ordered the closure of certain categories of manufacturing activities, mainly the non-essential ones, with the aim of minimising the movement and presence of personnel within working environments. The use of agile work was also encouraged where possible. Once the opening of all establishments where manufacturing activities were planned was restored, the 'Shared protocol for the regulation of measures to combat and contain the spread of the COVID-19 virus in the workplace of 14 March 2020' was published, updated over time, which prescribed the adjustments to be applied to manufacturing establishments in terms of personal and environmental hygiene measures in the workplace, as well as the various steps to be taken for adequate health surveillance. Legislative Decree 81/2008 was also amended by Legislative Decree 149/2020. As scientific research progressed, vaccines were formulated that were able to mitigate the effects of

COVID-19 on health and virus transmission; in order to maximise the effectiveness of the vaccination campaign, the Green Pass was introduced (Annex 1, ART. 9, L.D. 52/2021), which is compulsory for certain age groups to enter the workplace. With the 'Technical document on the possible remodelling of measures to contain SARS-CoV-2 infection in the workplace and prevention strategies, INAIL, April 2020' a risk level was calculated for COVID-19 in the manufacturing industry in relation to the various activities carried out. The measures proposed were more reactive than preventive in nature, taking action after the contagion curve had risen.

3. Testing the effectiveness of these solutions

INAIL, by means of the 'Regional COVID-19 INAIL Accident Card of 25 March 2022' (a periodic update of the regional cards published since the beginning of the pandemic), analysed the number of COVID-19-related workplace accident reports divided on a regional basis. It emerged that only a very small part of the total number of infections belonged to the manufacturing industry (never more than 10%), and this could be due to closures in the first place (in fact, most of the recorded infections occurred in industries that were not subject to closure, such as the food industry), and then to the containment measures established by the Protocol and the vaccination campaign. The highest number of contagions was recorded in regions such as Lombardy, where there is a high number of manufacturing activities. Punctual data on the number of contagions for each individual plant are not available, but only aggregates, which coincide with those presented in the INAIL document mentioned above. The fact that most cases are found in the sectors not affected by the first closures suggests that the isolation and closure of production units, although counterproductive from an economic and production point of view, were effective in containing the contagion in the initial stages. In the companies that remained open, and following reopenings for suspended activities, however, the only determining factor in containing the spread of the virus, in addition to the sanitisation and reorganisation of working environments, was the behaviour adopted by the workers themselves. Unfortunately, there are no data available to show the degree to which these voluntary measures have been adopted in correlation with the infection report data, since the companies were not asked to adopt any measurement of anti-infection behaviour, so it is not possible to make an objective judgement on the effectiveness of the measures and related sanctions proposed by the protocols adopted at national level.
This made it impossible, in almost all Italian companies, to determine a priori the probability of contagion and to adopt measures to avoid it. The only objective measurement was therefore that of infections after they had occurred. The only Italian companies that were able to intervene with preventive measures before contagions occurred were those that had adopted the 'B-BS Protocol for the management and monitoring of COVID-19 containment measures'.

4. B-BS protocol for the management and monitoring of COVID-19 containment measures

The only parametric model capable of measuring workers' preventive behaviour on a daily basis is Behavior-Based Safety, derived from Behavior Analysis. It entails a constant and parametric measurement of the behaviour underlying accidents at work and a contextual and continuous modification of the environmental contingencies that lead to an increase in safe behaviour. During the Consensus Conference held as part of the 14th European Congress of B-BS and PM (23-27 June 2020) the 'Protocol for the management and monitoring of Covid-19 containment measures', drawn up specifically for the contemporary emergency situation, was presented by A.A.R.B.A. and approved by many of the leading experts in applied Behaviour Analysis in the field of Organisational Behaviour Management. The adoption of a specific B-BS process for the management of the risk of COVID-19 infection

and the modification of hygiene behaviour is motivated by the recognition that the spread of the virus is attributable to risky staff behaviour. It is therefore necessary to prepare:
"❑ A system for pinpointing relevant behaviour;
❑ A parametric measurement system of prevention behaviour;
❑ A process of observation and feedback so that where behaviour is not congruent, it becomes so;
❑ A structured system for monitoring and maintaining the acquired behaviour over time.
The project is developed through the promotion and consolidation of hygiene behaviours so that they are stable, resistant to extinction and generalised, in compliance with current guidelines". The adoption of the process would therefore reduce the risk of contagion within organisations with repercussions on the community and ensure the continuation of normal activities in an operationally and economically sustainable manner.
The protocol provides for the definition of well-defined roles and working groups, composed of both specialised and non-specialised, but nevertheless adequately trained, personnel. The observer is the one who carries out the measurements of the critical behaviour identified by means of a pinpointing procedure, fills in the checklists and provides feedback immediately after the behaviour has been issued. The timing of the observation must be randomised, and the observer must measure the behaviour by parameters: the easiest to measure is the frequency of emission of the behaviour. Feedback must be given according to the principles of PIC-NIC Analysis. Weekly and monthly meetings should be organised to discuss the results obtained, as well as objectives and strategies for improvement. Monitoring of performance levels will be carried out by the B-BS Champion in collaboration with the Behavioural Analyst, who will act as supervisor.

4.1. Results of the implementation of the B-BS Protocol for the management and monitoring of COVID-19 containment measures

What emerged from the analysis of the observations made in the various locations of the companies considered is that a positive trend is observed in almost all of the graphs, and that in cases where negative peaks were present, action could be taken to bring the percentage of safe behaviour back to the desired levels through positive reinforcement and feedback, either immediately after the behaviour was issued or deferred during safety meetings. Without constant monitoring of the frequency of adoption of the behaviours under scrutiny, there would be no hard data on which to base a claim that the adoption rate is increasing or decreasing, only perceptions. In fact, the traditional audit-based method of inspection and sanctioning does not provide firm data on the actual frequency of preventive behaviours. On the contrary, in a structured process of behavioural measurement and modification, analysing the trend in the frequency of occurrence of behaviours over time allows one to promptly notice any decrease in behaviour that may occur, and to intervene promptly, without waiting for contagions to increase in order to take countermeasures. This is why, after each negative peak, there is an important increase in the rate of behaviour adoption, precisely thanks to the reinforcements and feedback provided following the trend analysis.
The results obtained in the companies examined show that the B-BS Protocol for the management and monitoring of COVID-19 containment measures is effective in increasing the frequency of reappearance of the desired safety behaviour in an extremely short time, thus reducing the time of exposure to the risk of infection.

5. Conclusions

The measures taken by governments during the world's largest pandemics since the Industrial Revolution to contain the transmission of infectious diseases have been

outlined. In all the pandemics considered, there was a lack of data on specific manufacturing-related contagions; even for the current pandemic, data are only available in aggregate form. Despite the measures implemented, there were still large numbers of deaths and infected in all pandemic events. This is mainly due to the inability to achieve a high degree of adherence to optimal behaviour by the population. The available data suggest that, despite the adequacy of the measures suggested or compulsory from a scientific-medical point of view, the prevention of infections was very often deficient in terms of the measures taken to ensure a high degree of adherence to the indications of virologists in terms of workers' behaviour. The measures issued by the Italian Government and the WHO do indeed provide an operational definition of the hygiene standards to be adopted, but they do not provide any scientifically based operational indications regarding the contingencies necessary to guarantee the immediate and constant availability of parametric data on the degree of utilisation of these standards. The control method envisaged for assessing compliance has remained the traditional audit, i.e. the one-off observation of the working environment, taking it as an effective indicator of what is happening in the establishment in question. The only systematic measurement carried out is the monitoring of body temperature, which is not a behaviour but a physical condition, moreover only indicative of a potential infection state already in place.

It is therefore clear that there is a need for a parametric support method that enables staff behaviour to be analysed, its variation to be monitored, its consequent analysis to be used to implement preventive measures to contain contagion, but above all that is capable of modifying these behaviours to obtain the desired ones, with the aim of zeroing out the transmission of the virus.

Among the methods adopted on a voluntary basis by Italian companies, only one goes beyond the single estimate of the spread of contagions and presents pro-active characteristics: the Behaviour-Based Safety process applied to the management and monitoring of COVID-19 containment measures. The systematic observation of behaviour, the recording of behaviour by means of checklists constructed using the pinpointing technique, the provision of feedback and positive reinforcement immediately following observation and the use of appropriate antecedents make it possible to monitor the trend in the frequency of adoption of the desired behaviour, with the aim of making it tend towards 100%, and at the same time to modify risky behaviour. A further advantage of this process is that it is possible to foresee possible closures of departments or establishments not following the detection of infected personnel, but prior to the infection. The data on preventive behaviour collected during this study seem to allow us to state that it seems logical to suggest the adoption of the 'B-BS Protocol for the management and monitoring of COVID-19 containment measures' in the current emergency pandemic situation in order to contain contagions in manufacturing activities, much more than simply providing workers with antecedents or unsystematic observations.

It also seems logical to have this protocol in place regardless of the active pandemic situation, in order to have an immediately adoptable method for future infections in all manufacturing industries.

The ability demonstrated by the companies under study, practically all of which were characterised by very high rates of preventive behaviour already during the first day of adopting the protocol, makes one very optimistic about their reactivity in the event of new variants of the coronaviruses already known, but also of any new pathogen, with a latency of a few days, if not a few hours, as soon as medicine is able to indicate preventive behaviour.