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Application of an Innovative Model for the Risk Management of COVID-19 in a Multinational Manufacturing Company

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Abstract: The COVID-19 incidence in 61 manufacturing plants in Europe (EU), North America (NA) and Latin-America (LATAM) was compared with the incidence observed in the countries where the plants are located in order to evaluate the application of an innovative model for COVID-19 risk management. Firstly, a network of local and global teams was created, including an external university occupational physician team for scientific support. In July 2020, global prevention guidelines for the homogenous management of the pandemic were applied, replacing different site or regional procedures. A tool for COVID-19 monitoring was implemented to investigate the relationship between the incidence rates inside and outside the plants. In the period of May–November 2020, 565 confirmed cases (EU 330, NA 141, LATAM 94) were observed among 20,646 workers with different jobs and tasks, and in the last two months 85% EU and 70% NA cases were recorded. Only in 10% of cases was a possible internal origin of the contagion not excluded. In the EU and NA, unlike LATAM, the COVID-19 incidence rates inside the sites punctually followed the rising trend outside. In conclusion, the model, combining a global approach with the local application of the measures, maintains the sustainability in the manufacturing industry.

Keywords: SARS-CoV-2; manufacturing industry; occupational health; occupational COVID-19 transmission

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1. Introduction

In December 2019, in the city of Wuhan (Hubei, China), an epidemic outbreak of cases of atypical pneumonia of initially unknown etiology was observed [1]. In January 2020, it was attributed to a new coronavirus, called SARS-CoV-2, causing the coronavirus disease 2019 (COVID-19) [2]. On 30 January 2020, the World Health Organization (WHO) indicated that the SARS-CoV-2 outbreak was a Public Health Emergency of International Concern, and on 12 March 2020, the WHO declared the condition of a COVID-19 pandemic [3]. Since this time, the pandemic has been continuously present worldwide, posing not only a threat to global health, but also raising major concerns about global economic sustainability. These problems are due to the heavy impact of both the pandemic itself and all of the prevention measures adopted, in all productive settings [4].

In fact, although the majority of the occupational clusters of COVID-19 were reported in health care settings, some industrial settings also suffered outbreaks all over the world, contributing to the local spread of the pandemic [5]. Of specific concern are manufacturing sectors, where maintaining the production of essential goods is important for public health and the possibility of implementing "stay-at-home" policies is limited. As such, while white collars could move their workplace home following the outbreak of the COVID-19 pandemic, blue collar workers had to be considered essential workers exposed to a new risk.

This necessarily had to be faced with little or no proven best practice and guidelines [6]. In fact, manufacturing plants are a socially interactive system, relying on the collaboration of many people in close contact with colleagues, and also with external contractors and suppliers. Since the beginning of the pandemic, manufacturing industries have undergone business closures, process disruption and financial loss, raising global concern about the availability of primary goods [7]. The management of the COVID-19 pandemic, therefore, seemed to need a new approach, tailored to the specific work setting, but also based on a continually updated scientific understanding of the virus transmission mechanisms, local epidemiology and disease characteristics [8].

In order to assess the occupational risk of infection in workplaces, a methodological approach has been proposed, classifying working activities as high, medium-high, medium-low or low risk based on three parameters: the exposure probability, proximity index and aggregation factor [9,10]. In this classification, manufacturing workers are generally assessed as low exposure risk, depending on whether frequent and/or close contact with the general public or third parties is involved [9,10].

However, although risk assessment must always be the preliminary approach for the adoption of adequate preventive measures, national regulations and the production needs of individual plants can lead to very different risk management in a multinational company. The purpose of this study was therefore two-fold: firstly, to define a homogeneous risk management approach in the various plants of a multinational company; secondly, to evaluate its effectiveness by comparing the incidence and trend of COVID-19 cases in the production plants with those observed in the countries where they are located. To our knowledge, there are no studies in the literature that have evaluated the effectiveness of risk management in protecting employees and ensuring production continuity in the manufacturing industry.

2. Materials and Methods

2.1. Study Population and Company Description

The study was conducted in 61 plants belonging to three different business areas of the same multinational company involved in the production of essential goods such as consumer and professional tissue paper, personal care products and medical products. Plants in joint ventures were excluded from the study. The plant locations are: 43 in Europe (EU), 10 in North America (NA), and 8 in Latin America (LATAM) (Table 1). All of the company employees not working at home during the time study were eligible to enter the study. The population investigated included 20,646 workers with different jobs and tasks. The data were collected in an anonymous form in order to comply with privacy country regulations and no further sociodemographic data on the workers were available.

Table 1. Number of sites and workers included in the study, according to regional area.

Europe			North America			Latin America		
Country	**N. Sites**	**N. Workers**	**Country**	**N. Sites**	**N. Workers**	**Country**	**N. Sites**	**N. Workers**
Germany	6	2716	US	9	2232	Mexico	5	3337
France	6	2038	Canada	1	145	Brazil	1	343
Netherlands	5	1243				Chile	1	304
UK	6	1190				Colombia	1	194
Spain	3	1122						
Russia	4	1107						
Slovakia	1	1024						
Poland	1	870						
Sweden	3	831						
Italy	4	689						
Austria	1	515						
Belgium	1	426						
Finland	1	223						
Turkey	1	97						
Total	43	14,091	Total	10	2377	Total	8	4178

2.2. Risk Management Model: Creation of the Network of Teams

The first step in implementing the model was the creation, in May 2020, of a network of teams, to carry out responses outside normal operational procedures and to promote rapid problem solving under high stress and chaotic conditions in the pandemic landscape (Figure 1). The network of teams includes: one Health, Safety and Environmental (HSE) Local Team (LT) in each productive site; the Country Management Team (CMT), including the legal employers for each country, to provide a view on the countries regulations and perspectives; the Central Communication Team (CCT), to support risk communication strategies in the sites; an external Medical University Team (MUT) of academic occupational physicians for scientific support in implementing all of the global measures adopted. The network of teams is coordinated by the Global COVID-19 Team (GCT), that includes the HSE Regional Director (RD) for each geographic area (EU, NA, LATAM) or Business Unit, as the point of contact of specific groups of LTs, and the points of contact for the CMT, the CCT and the MUT, respectively.

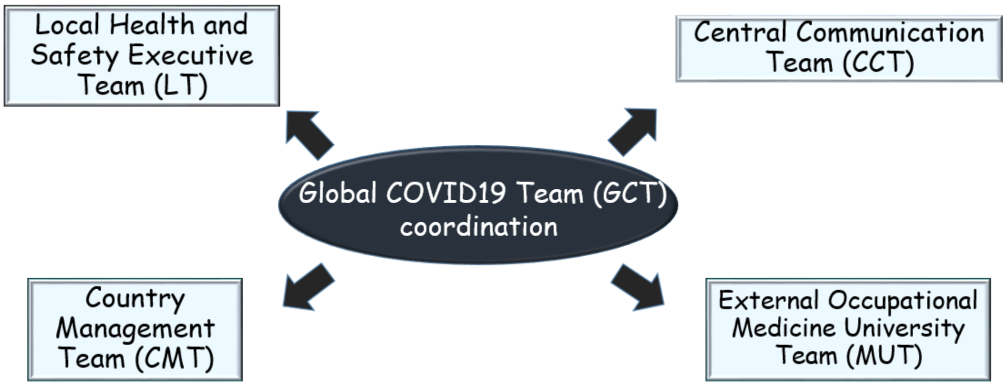

Figure 1. The network of teams involved in the study.

Multidisciplinary management and cooperation are essential aspects of the network of teams, because the COVID-19 crisis presents a high degree of complexity requiring different expertise. The GCT, in fact, is able to analyze and rationalize all of the demands, making all decisions and preparing guidelines based only on information scientifically validated by the MUT, and periodically updated taking into account new proven scientific evidence. Meanwhile, the network of LTs constantly updates measures adopted according to country regulations, and offers effective operational guidance to all of the sites. This serves to translate general indications into actual operating procedures, choosing the most correct measures to prevent exposure to the risk of contagion and to protect workers health in different epidemiological contexts.

A two-way communication strategy among the teams, therefore, was primarily adopted, including regular sharing of information about the evolving knowledge of the pandemic. In this sense, the GCT engages open, continuous communication with LTs on all local issues, focused on applying the overall best practice decided at a global level to the specific local context. This communication also allows the GCT to receive input from the sites as a key point of the model, because it allows the network of teams to keep fully informed about the continuously changing scenario.

2.3. Risk Management Model: The Operative Tools

To perform the global risk management of the COVID-19, the GCT created different tools: global guidelines for the implementation of the prevention measures, a global epidemiological surveillance system for the monitoring of COVID-19 cases in the company and an active alarm system for the management of cases in the plants (Figure 2).

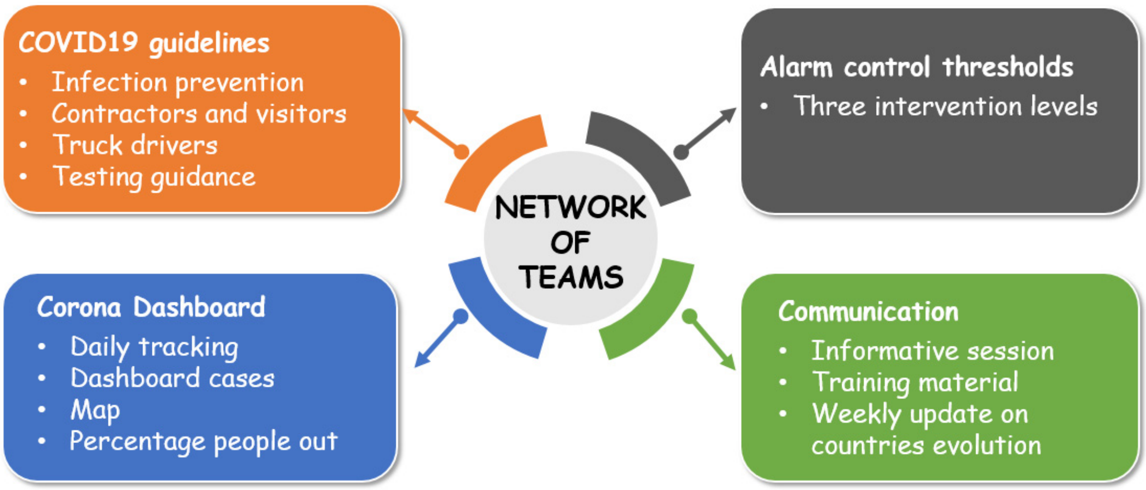

Figure 2. The global model developed by the Global COVID-19 Team.

In July 2020, global guidelines, prepared and approved by the network of teams, were applied in all of the sites, replacing the different regional or site procedures prepared in March 2020 and implemented without a homogenous management of the COVID-19 risk. The guidelines were applied from a preventive perspective, complying with local country regulations, and aiming to reduce to a minimum the risk of infection of employees, in accordance with a risk assessment approach performed by the LT at plant level using the criteria of exposure, proximity and aggregation [9,10].

In this view the prevention measures included in the guidelines were based on the scientifically validated common recommendations [11]:

- physical distancing (2 m);
- use of certified medical masks and, if a proper distance cannot be maintained, additional PPE, such as a face shield, goggles, close-fitting safety glasses, and in a few specific situations, gloves (for delivering or accepting equipment, spare parts or documents, etc.);
- hand hygiene and proper workplace cleaning and disinfection practices;
- isolation of confirmed cases and quarantine for suspected cases;
- testing strategies, providing recommendations on the usefulness and limitations of molecular, antigenic and serologic tests, to be applied according to the local availability [12].

In particular, physical distancing, by adopting engineering and administrative measures and quarantine, was among the key measures taken to control the epidemic in the sites [13–15]. In this view, an automatized system for the assessment of distancing and time of contact during working activities has been tested in some pilot sites, and was implemented by the beginning of 2021. This system has shown to be helpful to support contact tracing and to improve the proximity risk assessment.

An example of application in the guidelines of only validated scientific evidence was the indication that only medical masks certified in accordance with safety and performance requirements (such as regulation EN 14683:2019 and EN ISO 10993-1:2010, or similar) should be worn [16,17]. Although in some documents the use of non-medical face (cloth) masks is indicated for the community, there is scientific evidence that they are less effective than medical masks as a mean of source control, also owing to the lack of established standards [18,19]. Previous papers, moreover, have reported that wearing a non-standardized face mask may create a false feeling of security, leading to relaxing physical distancing and touching the face more frequently [20,21].

In the risk management strategies, great importance was attributed to the entry on site of both external company employees (visitors) and contractors, particularly truck drivers. These workers were considered to pose a high risk of COVID-19 transmission due to their activities in different plants. For this reason, specific procedures were applied to prevent entry if symptomatic, and to stipulate stricter separation rules to avoid any contact with internal employees in all possible circumstances and areas. Different routes and facilities dedicated to contractors on the sites were implemented, and areas where maintenance activities were performed by external companies were isolated.

The GCT also organized the epidemiological surveillance of COVID-19 cases in the company, through the creation of an internal COVID-19 Dashboard (CoDa). This is a tool for real time monitoring of the spread of COVID-19 within the sites that allowed possible sources of contagion to be identified at an early stage.

This tool was also the source for the collection of the data used to calculate the incidence and the trend of COVID-19 cases in the plants.

The CoDa makes computerized collection of the data compiled daily by the LT of each site, in accordance with privacy regulations. The data report general information on each plant (map, description of the separation areas, ventilation system, number of employees, etc.), and anonymous information on all confirmed (RT-PCR positive) and suspected cases (onset of symptoms or close contact with a confirmed or suspected case) at the site.

The CoDa provides clear, simple summary visual information on a map, where countries with new confirmed cases in the given period are indicated in red (Figure 3), and a table shows where the new confirmed cases developed in the last 7, 14 and 21 days at each site. Moreover, the CoDa includes daily tracking of confirmed and suspected cases. An anonymous list is made both of confirmed cases, reporting the dates of sick leave and diagnosis, and the reason for testing (onset of symptoms, close contact inside or outside the plant), and of suspected cases, reporting the date of sick leave, the reason for suspicion (onset of symptoms, close contact inside or outside the plant), and whether the RT-PCR test was performed.

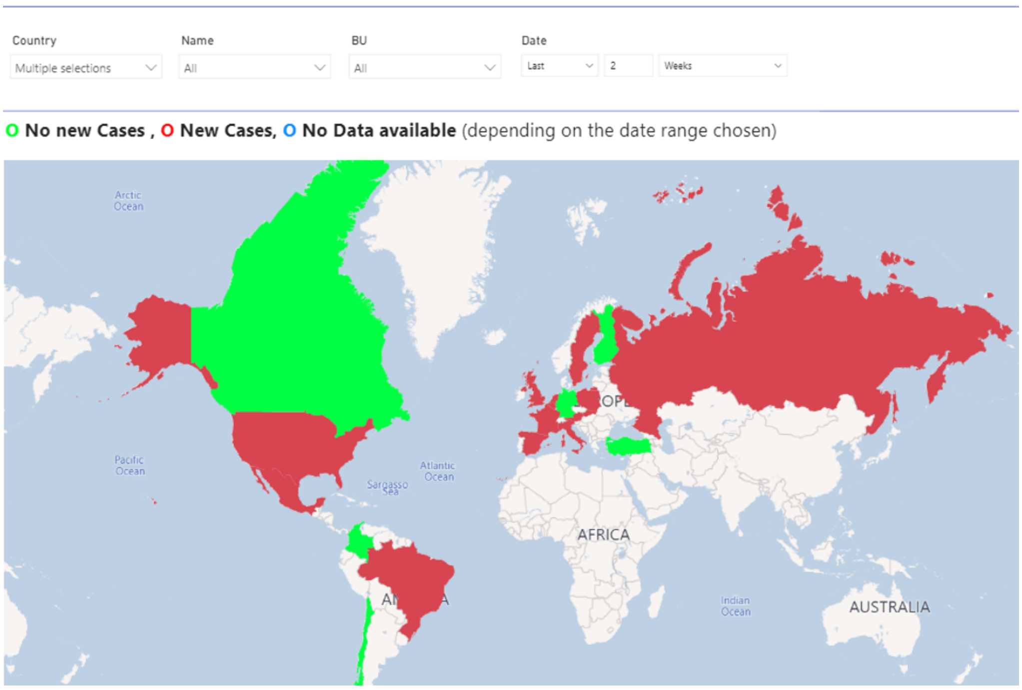

Figure 3. Example of graphic representation of new confirmed cases by COVID-19 dashboard map.

In September 2020, an active alarm system stipulating intervention thresholds was created to ensure that appropriate countermeasures are implemented in a timely, dynamic manner in response to a possible infection spreading in a site. The system stipulates that, if two or more confirmed cases have been identified in the plant in the last 21 days, the LT must investigate the possible epidemiological relationship between the cases, inform the RD and, if necessary, request the support of other GCT components. Moreover, in situations of two or more confirmed cases with a possible epidemiological relationship, the LT, together with the RD and the MUT, must evaluate further measures to be implemented.

A further key point of the model approach and of the tool application has been the risk communication cascade supplying all of the company employees with the same global, scientifically validated information about COVID-19. For this purpose, information interventions were organized in the first week of September 2020, projecting simple, short videos, translated into the different languages spoken in the sites, to improve the global knowledge of COVID-19, and of the company measures implemented. This information campaign was set up by the MUT and CCT and also included, as requested by the sites, clear recommendations on the measures to be adopted in social life and outside work settings. Moreover, the LTs were directly trained by the MUT during specific webinars organized to explain the scientific bases of all of the measures adopted, particularly if stricter than the local regulations. The MUT and the CCT also shared the same informative materials with each site to help them acquire a similar perspective on specific training of all of the workers in the measures adopted in the plants.

2.4. Evaluation of the Application of the Model and Statistical Analysis

Evaluation of the model was performed by analyzing the relationship between the outbreak inside and outside the sites. The incidence rates per 10,000 inhabitants were calculated twice a month (period 1–15 and 16–30/31) from May to November. This consisted of summing, by geographical area (EU, NA, LATAM) for each time period, the confirmed cases recorded among the workers and the total number of workers in the plants. In the same way, summing by geographical area for each time period, the confirmed cases were recorded and the general population in each country where the plants are located [22]. To compare the time series of the inside and outside outbreaks, cross-correlation and similarity analysis were implemented. These procedures were used to check whether the trend of infections within the plant is independent or associated with the trend of the pandemic in the general population. Cross-correlation between time series, over a range of two successive time lags (lag 0, related to the same 15 days, and lag 1, related to the previous 15 days), was implemented to compare the time series of rates in the general population with those in the plant. This allows the determination of the time lag that maximizes the strength of the correlation between the time series by observing the size of the correlation coefficient and its statistical significance, defined as greater than twice the standard error ($p = 0.05$).

Similarity analysis was also applied to measure the distance between the sequences of country rates (target series) and plant rates (input series), while taking into account the ordering of the rates. When the trend of infections inside the plants reflects the trend observed outside the plants, then the distances between the ordered points of the series will be minimal and therefore the two series will be similar. Similarity analysis was performed on the normalized time series, to avoid the influence of chance and specific differences between the site and area populations (as in the testing strategy, contact tracing, etc). Absolute deviation (AD) and dynamic time warping (DTW) measures were used as similarity metrics [23,24]. AD is calculated by summing the absolute differences between each rate in input sequence and the corresponding rate in the target sequence used for comparison. DTW is a powerful dynamic-programming technique for measuring similarities between two sequences that may vary in time or speed. All analyses were conducted using SAS 9.4 software [25].

3. Results

After starting the progressive application of the model in May 2020, the global number of confirmed cases up to November 2020 was 565 (EU 330, NA 141, LATAM 94), and internal site inquiries showed that only in 10% of cases could a possible origin of the contagion in the workplace not be excluded. More cases in the EU were due to car-pooling. Most of the confirmed cases at the sites were recorded in October and November 2020, both in the EU (85% of all cases) and NA (70% of all cases), following the second wave trend observed in the general population [26].

Moreover, the application of the model caused 4323 employees (EU 1489, NA 998, LATAM 1836) to be placed in preventive quarantine in the period May-November 2020.

A significant cross correlation between the incidence rates inside and outside the sites was observed both in the EU and NA, with higher coefficients at lag 0 than at lag 1, while no significant correlation was observed in LATAM (Table 2). Analysis of the normalized time series (Figure 4) showed a similarity of the slope of the incidence rates, that was higher in the EU and NA than in LATAM, as confirmed by a smaller AD and DTW in EU and NA (Table 2). These results indicate that the trends of infections in the plants punctually followed the temporal trend of the epidemic in the general population in EU and NA, but not in LATAM.

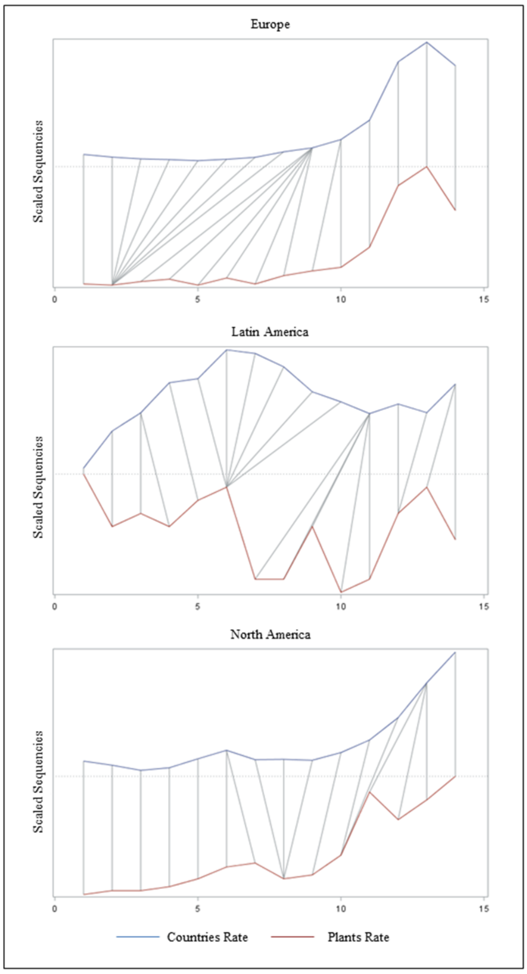

Figure 4. Warping path plot between the normalized plant rate (input) and normalized countries area rate (target) time series by geographic area.

Table 2. Cross-correlation coefficients and similarity metrics by geographic area.

Geographic Area	Cross-Correlation				Similarity	
	Lag 0		Lag 1		AD	DTW
	r	*p*	r	*p*		
Europe	0.99	<0.001	0.82	0.002	3.83	1.75
North America	0.88	0.001	0.07	0.008	3.36	1.45
Latin America	−0.33	0.223	0.10	0.714	4.76	2.10

AD = absolute deviation; DTW = dynamic time warping.

4. Discussion

As detailed in the results, we report the first data on the incidence of confirmed and suspected COVID-19 cases in the plants of a multinational company of the manufacturing industry, located in different geographic areas, after the application of an innovative model for the risk management. The model approach was based on two main principles: firstly, to protect the workforce because 'nothing is worth an infection', by adopting operating procedures and processes designed to keep the sites safe; secondly, to ensure business continuity, by anticipating potential changes and modeling the manufacturing plants organization.

Particularly, the application in all of the plants of the same company guidelines prepared by the GCT is based on the principle that since COVID-19 is a pandemic, a global approach should be the right strategy for effective risk management. This approach seemed necessary considering the previous wide range of local responses to the pandemic, that were not always scientifically based and often conflicting. In this regard, administrative measures had previously been taken to reduce "sickness presenteeism", since in some countries this may be a major factor contributing to the occupational spread of COVID-19 [27]. Fear of losing their job or income may lead workers to continue working, even when exhibiting symptoms compatible with COVID-19 [28]. To oppose this not evidence-based approach, we have developed global guidelines to prevent COVID 19 frankly symptomatic employees from entering the workplace, as also to manage the worst-case scenario in which the onset of the worker's symptoms occurs within the site. In any case, measures have also been envisaged to eliminate or at least to reduce the risk of COVID-19 transmission from asymptomatic, pre-symptomatic or mild-symptomatic employees.

Specific measures to limit the contagion in non-health care occupational settings have been suggested at country level, although their use is poorly recognized [14,29]. However, in a survey of June 2020, Billock et al. (2021) reported that the use of hazard controls to prevent COVID-19 infection was lower than 50% in non-remote non-health care US workers, suggesting that employers can support the health protection of their employees against COVID-19 through hazard control [30]. On the other hand, a general integrative approach using a total health worker framework has been suggested for the COVID-19 management in workplaces [31]. In any case, to the best of our knowledge, our study is the first to describe a global model of risk management and the results obtained after its application in term of the incidence in the sites.

In fact, our findings indicate that the model was able to contain the spread of the infection in the sites, and in parallel a strict policy of contact tracing and testing allowed the confirmed cases to be identified. In EU and NA, a similar trend of infection was observed in the workers at the plants and in the general population, and analysis of the cases in each plant confirmed that there were few situations of possible internal contagion among employees. Also in these situations, however, the set of measures adopted was always able to contain the number of cases, achieving rapid resolution of the possible outbreaks. The containment of COVID-19 infection was also observed in LATAM plants, where the number of cases mostly did not follow the increased spread of the infection observed in these countries. In fact, employees were considered suspected cases even with minor symptoms or close contact, and immediately moved away from the sites and quarantined, even before diagnostic test confirmation, whereas this did not happen for the general population, allowing the spread of the infection in the community [32].

Nevertheless, throughout the study period it was possible to keep all of the plants open globally, without any change in the production capacity due to the COVID-19 situation. In any case, the COVID-19 will have long lasting effects on the sustainability of manufacturing organizations, obliging companies to restructure their operations in order to protect their employees without interrupting production. The coming months will remain extremely challenging for plants, but the crisis is creating the opportunity to review the way work is done, and to emerge from this pandemic with safer, more productive and resilient manufacturing operations, and a greater awareness that protecting the essential worker health means protecting the global community health and wellbeing.

There are some study limitations. Firstly, COVID-19 incidence outside the plants was calculated as country incidence, not considering possible local outbreaks in the regional area where plants were located. Then, the data were collected in anonymous form and no further analysis on the effect of socio-demographic variables of workers on the observed results was possible.

5. Conclusions

Our risk management model has shown that it is possible to keep COVID-19 outbreaks under control in manufacturing plants, thanks to a global approach, continuously updated to the new scientific evidence, combined with the local application of preventive and protective measures. However, further investigations are needed to verify whether it is also effective in other non-healthcare work contexts where essential workers who cannot carry out their work from home are employed.

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