



# COVID-19: unbalanced management of occupational risks—case of the analysis of the chemical risk related to the use of disinfectants in the dairy industry in Morocco

Hafida Rachidi<sup>1,2</sup> · Samir Hamdaoui<sup>1</sup> · Imane Merimi<sup>3</sup> · Jamae Bengourram<sup>4</sup> · Hassan Latrache<sup>1</sup>

Accepted: 5 April 2021 / Published online: 17 April 2021

© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2021

## Abstract

Moroccan employers have a strong responsibility for the safety and health of their employees in the workplace and for protecting them from the risk of COVID-19 and any occupational hazards, as required by Moroccan law. As a consequence, industries, including the agri-food sector, have put in place preventive measures to deal with this pandemic on several fronts, including the use of hydroalcoholic products and bleach for personal and surface disinfection. These disinfection actions may eliminate or reduce the risk of coronavirus infection, but the increased use of these products by employees could lead to serious health problems and increase the occupational chemical risk in the event of uncontrolled exposure. In order to analyze this risk in the dairy industry in Morocco, we have launched a qualitative and quantitative study to identify and assess the severity of chemical risk to which its employees are exposed. This involves an analysis of the safety data sheets [MSDS] of the disinfectants used and a health and safety survey of the users of these products, particularly for hand disinfection. This analysis showed that this chemical risk is omnipresent and prevention measures are partially adopted. Indeed, the strengthening of health safety measures to combat COVID-19 has significantly increased this risk, resulting in a remarkable imbalance in the assessment and management of occupational risks in this industry. These results have led us to propose corrective and preventive measures against this risk to interested parties and to adopt an integrated management of food and occupational health risks in a single system. This is the use of the Risk Analysis—Critical Control Points (HACCP)-Tool for a First Risk Assessment by Activity Analysis (OPERA) approach, which we developed and proposed in a previous study, for a simplified management of chemical risk in the food industry, especially in small- and medium-sized enterprises.

**Keywords** COVID-19 · Chemical risk analysis · Food industry · HACCP-OPERA · Morocco

---

Responsible Editor: Lotfi Aleya

✉ Hafida Rachidi  
rachidihafida@yahoo.fr

<sup>1</sup> Research team of “Bioprocesses and Bio interfaces”, Faculty of Science and Technology, Sultan Moulay Slimane University, Béni Mellal, Morocco

<sup>2</sup> Research team E2SN: Electronic Systems, Sensors and Nanobiotechnology, ENSAM, Mohammed V University, Rabat, Morocco

<sup>3</sup> Laboratory of Applied Analytical Chemistry, Materials and Environment (LC2AME), Faculty of Sciences, University Mohammed First, Oujda, Morocco

<sup>4</sup> Industrial Engineering Laboratory, Faculty of Science and Technology, Sultan Moulay Slimane University, Béni Mellal, Morocco

## Introduction

In industry, employees who are subjected to excessive or repetitive stress most often develop health problems or reactive behaviors, which weighs heavily on the productivity and quality of organizations' products and services, reduced performance, absenteeism, safety, and job instability. The constraints put in place by the accomplishment of the task can be estimated in terms of workload, physical load, sound risk, light risk, biological risk, chemical risk, etc., which significantly influences the safety and health of workers.

Indeed, several legislative texts at the international and national levels have focused on the preservation of workers' health and the prevention of occupational hazards. In Europe, this is the European framework directive on safety and health at work (directive 89/391 EEC) adopted in 1989.

This directive requires employers to adopt appropriate measures to improve safety and health at work. It constitutes, together with other specific directives, the basis of European legislation in the field of safety and health (European Agency for Safety and Health at Work 2020a).

Similarly, in Morocco, the employer is responsible for the safety and health of its employees. Under Moroccan law, the employer must ensure that work premises are kept in a good state of cleanliness and present the conditions of hygiene and sanitation necessary for the health of the employees (Official Bulletin 2004a). In addition, employers are prohibited from permitting their employees to use products or substances, apparatus, or machinery that are recognized by the competent authority as likely to affect their health or safety (Official Bulletin 2004b).

At the national level, as in the rest of the world, the spread of the COVID-19 pandemic is placing a great burden on health care systems and damaging economies and industry. Moroccan employers are responsible, then, for the health safety of their employees in the workplace and for preventing the risk of COVID-19 and any occupational hazards, as stated, above, by Moroccan law.

Since food industry employees must continue to travel to their usual place of work, it is essential to protect their health and safety by urgently implementing adequate measures to prevent worker exposure to or transmission of the virus and to reinforce food hygiene and sanitation practices (FAO/WHO 2020), as the virus responsible for COVID-19 is transmitted from person to person through close contact or droplets; this result was confirmed by Tran et al. (2012), Liu et al. (2020), and Ong et al. (2020). Similarly, hand contact with a contaminated surface (passive vector) followed by contact with the eyes, mouth, or nose is also an important mode of transmission of SARS-CoV-2, indicated by Xiao et al. (2020), Qiu (2020), and Cereda et al. (2020) especially if these surfaces are made of plastic or metal (Van Doremalen et al. 2020).

Therefore, the industries of the food-processing sector in Morocco have put in place several measures to cope with this pandemic such as distancing (WHO 2020), wearing masks, and the use of disinfectants (hydroalcoholic products, soap, and bleach) for personal and surface disinfection. Alcohol-based disinfectants used at concentrations of 70% to 80% significantly reduced the infectivity of enveloped viruses, such as COVID-19, so chlorine-containing compounds would have similarly virucidal properties (Cereda et al. 2020).

These disinfection measures would protect employees from biohazard (COVID-19) (Cereda et al. 2020). However, the increased use of these products by employees could lead to serious health problems (occupational accidents and diseases) and increase exposure to chemical risks in the workplace, particularly in the absence of inadequacy of preventive measures (INRS 2020a, 2020b).

Chemicals that come into contact with the human body (through the respiratory tract, skin, or mouth) can disrupt the body's functioning. They can cause:

- Acute poisoning, with more or less serious effects, burns, skin irritation, itching, convulsions, drunkenness, loss of consciousness.
- Chronic intoxications: repeated contact with certain chemical agents, even at low doses, can damage the lungs, nerves, brain, and kidneys and cause eczema or asthma, silicosis, cancer, and fertility disorders (INRS 2020b).

It is known that pathologies due to chemicals can appear several months or years after exposure. In the case of occupational cancers, they may appear 10, 20, or even 40 years after exposure (INRS 2020b).

In particular, hydroalcoholic gel, used for hand disinfection during this pandemic, is recognized as a flammable product, sensitive to ignition sources (flames, hot surfaces, sparks, etc.) and may cause explosions and several health problems (INRS 2020b). The same goes for bleach, which may cause symptoms such as coughing, shortness of breath, tearing or burning sensation in the eyes, and nasal discharge, especially when mixed with hot water or an acid (Chen 2020).

Exposure to these chemicals in the workplace, with a view to combating the COVID-19 pandemic, requires special attention and an assessment of the chemical risk incurred alongside the risk of coronavirus.

Our study is mainly aimed at ensuring a balanced management of occupational risks; that of COVID-19 and of the chemical risk related to the use of hand disinfectants, particularly in the food industry, as a sensitive sector requiring a good control of the health risks of employees and food products. This ensures a healthy and safe professional environment and consequently a food production of good microbiological and chemical quality.

The study is mainly based on the risk analysis and its components, namely, risk assessment, management, and communication. It is a pragmatic approach to controlling risks. The assessment of health hazards is deeply concerned with the application of the precautionary principle. The essential aim is to provide risk managers with information to enable them to reach more objective decisions on the most appropriate measures in terms of health security and to communicate about them (Rachidi et al. 2012).

In order to analyze the professional chemical risk in question, we launched a qualitative and quantitative study in the dairy industry in Morocco. It is about:

- Identifying and assessing the severity of the chemical risk of disinfectants to which employees are exposed during this COVID-19 pandemic;

- Proposing corrective and preventive measures to ensure the health safety of employees and the improvement of working and food production conditions;
- Proposing and adopting a simplified approach to integrated assessment and management of occupational and food risks, particularly in small- and medium-sized enterprises, without recourse to metrological and/or bio-metrological methods

## Methodology

Our occupational risk analysis related to the exposure to chemical risk in the dairy industry in Morocco during the COVID-19 pandemic was based on the following steps:

Firstly, we conducted a qualitative analysis that collected data on the disinfection products used by employees during the COVID-19 pandemic. We then developed a chemical risk assessment based on the MSDS of the disinfectants used.

Secondly, to convert the information collected into figures, we conducted a health and safety survey of 90 individuals in three industries. These individuals used hand sanitizers. This study was conducted to describe, explain, and predict the main factors influencing occupational safety related to exposure to chemical risk in these industries. This survey would make it possible to express individual and collective opinions on the chemical risk incurred, to gather information on the exact effects following exposure to these products, and to evaluate knowledge and practices in terms of prevention. This will allow an empirical observation and its connection with the conceptual dimension of research and a vision on the dominant variables to prioritize them.

It is then a matter of proposing improvement actions and participating in the development of an integrated management of the health risks of the food product and the operator at the workstation for a simplified analysis of the chemical risk related to the use of disinfectants. This will be achieved by adopting the HACCP-OPERA approach, which we have developed and proposed in a previous study (Rachidi et al. 2016a). This method is a simplified tool for chemical risk assessment and management in the food industry, especially small and medium enterprises, without the need for metrological and bio-metrological methods. It brings together two approaches usually implemented separately: the HACCP approach and the OPERA method (Rachidi et al. 2016a).

The HACCP (Hazard Analysis and Critical Control Point system: a system which identifies, evaluates, and controls hazards which menace food's "safety") according to the Codex Alimentarius version 4 (2003) (Tixier 2008). It is a structured approach for building assurance of food safety. It is also a compatible and complementary tool to ISO 9000.

HACCP is a harmonized and organizational method based on internationally recognized standards and guidelines.

---

> The HACCP implementation is based on 7 principles:

- 1 Hazard analysis (causes, preventive measures)
- 2 Identification of critical control points (CCP)
- 3 Establishment of target values and tolerances for each CCP (critical limits)
- 4 Establishment of a monitoring system for each CCP
- 5 Establishment of corrective actions
- 6 Verification
- 7 Establishment of documentation

> The OPERA method (Tool for the First Assessment Analysis Risk by Activities) (Burgundy Franche Comte, 2008). The OPERA method is a preliminary evaluation tool of chemical risks that can be completed by a metrology. It assesses the risks in health and safety at work and fire by taking into account the actual business operators. It allows an overall assessment of chemical risks to the position and/or prioritization of different work phases. It helps to prioritize the axis of action to helping the definition of preventive measures to be implemented. Moreover, this method allows a predictive risk assessment in case of process choice modification for a same product or of product modification.

> The OPERA-HACCP approach, which we propose, is based on 12 steps including 7 principles (Rachidi et al. 2016a):

- 1 Constitution of the team HACCP-OPERA: It is essential that the host of the HACCP-OPERA team sets up a working group bringing together the various stakeholders, occupational health service, medical profession...
  - 2 Inventory and description of products, personnel, and environment work: This is the most important step; it consists the following:
    - 2.1 To identify and collect data on all chemicals used, generated, or stored in workstations, and classify and view their properties. Also, expired or unused products for some time will be removed by procedures that respect the environment;
    - 2.2 To describe the personnel, workstations, and collective and personal protective equipment.
  - 3 Determination of the intended use of the products: identifying the intended use of the product, where it draws up the conditions of storage and use of the products by the operator;
  - 4 Establishment of the list of operations: The list of operations shall be established and the team should investigate the possibilities of risk exposure, accidents, and incidents, based on statistics of diseases and injuries and their analyses;
  - 5 Confirmation of the list of operations instantly;
  - 6 Analysis of dangers and preventive measures (**principle 1**):
    - 6.1 Hazard identification: The list of operations shall be established, and the team should investigate the possibilities of risk exposure, accidents, and incidents, based on statistics of diseases and injuries and their analyses;
    - 6.2 Identification of possible damage;
    - 6.3 Identification of preventive measures: identifying preventive measures to eliminate the risk or reduce its occurrence to an acceptable level.
-

## Determination of Critical Control Points (CCPs) for the control method by the OPERA (principle 2):

7.1 Assessment of the severity of chemical risk: This is to assess the severity of the risk of chemical substances from the equation “ $GR = [(A / B) + C] * D$ ” of the OPERA method (according to Cram Burgundy Franche Comte);

7.2 Identification and evaluation of critical points (CCPs) are often difficult to assess with the HACCP only: The severity of the risks of chemicals, evaluated and selected by the OPERA method, therefore allows identifying and estimating the critical points based on the factor *D*.

1. Determining the critical exposure limits for each critical point (**principle 3**): Critical limits correspond to the extreme values acceptable with respect to operator safety;
2. Setting up a system for monitoring risk exposure for each CCP (**principle 4**): Critical limits correspond to the extreme values acceptable with respect to operator safety;
3. Establishment of a corrective action plan (**principle 5**): Corrective actions are predetermined action by the multi-disciplinary team and should be applied immediately when the monitoring system reveals a deviation indicating loss or lack of control of a critical point;
4. Application of the verification procedures (**principle 6**): This step is to define activities of follow-up to verify that the HACCP-OPERA system is suitable and working properly;
5. Record: the single document (**principle 7**): The employer can record the results of the risk assessment; it has the choice of the method deemed most appropriate to their needs.

The HACCP-OPERA chemical risk assessment that we have proposed is based mainly on the quotation of R-phrases. These R-phrases have now become H-phrases according to the CLP Regulation (meaning “Classification, Labelling, Packaging”), which has progressively replaced the pre-existing European system and repealed it completely on June 1, 2015 (except for special provisions) (INRS 2020c). In this case, we are called upon, then, to update the HACCP-OPERA method according to the new hazard statements H, using the correspondence between the two designations H and R to evaluate the chemical risk in question (Guichard et al. 2011).

## Results and discussion

Concern about the impacts of chemicals on health and the environment is widespread. They can greatly impede progress and the achievement of development goals. In this context,

several directives and legislative texts have been created to protect the health and safety of workers against risks related to chemical agents at work, citing as non-exhaustive the European Directive 98/24 / EC - risks related to chemical agents at work and Regulation (EC) no. 1272/2008 concerning the classification, labeling, and packaging of substances and mixtures (European Agency for Safety and Health at Work 2020b).

In the same sense, Morocco has introduced an important legislative (Official Bulletin 2004a; b) and normative arsenal that allows for a healthy assessment and management of chemicals, which could help reduce the financial burden, health problems, and pollution levels posed by the unsustainable management of these chemicals. According to the Moroccan standard NM 03.2.100, a certain number of dangerous products are listed according to the risk they represent (toxic, flammable ...). Also, a system of classification, packaging, and labeling of dangerous preparations is presented by the NM 03.2.101. NM 03.2.103 gives instructions for the preparation and drafting of a safety data sheet for chemicals (Department of Surveillance and Risk Prevention, Ministry of Energy, Mines, Water and Environment, Morocco 2013).

This study focuses on the identification and evaluation of the chemical risk due to the use of hand sanitizers in the dairy industry in Morocco during the COVID-19 pandemic. It first focused on diagnosis and analysis of the toxicological information and data provided on the MSDSs of the disinfectants used in these workplaces (Table 1). These sheets are based on European regulations, which are correlated with Moroccan regulations.

The results of this first analysis of the MSDSs (Table 1) showed that bleach can cause serious health problems if exposure is not appropriate and the safety instructions and directions for use are not followed. Similarly, the use of a hydroalcoholic hand gel can lead to significant health risks if exposure exceeds tolerable limits and if individual and collective preventive measures are not used or are insufficient.

In order to gather data on the exact health effects due to exposure to these disinfectants and to assess perceptions and practices in terms of prevention, we conducted a health and safety survey in the industries in question. Out of 90 employees surveyed, 40 responded to our questionnaire (Annex 2).

This study showed that 100% of the survey participants used alcohol-based hand disinfection gel during the COVID-19 pandemic (Fig. 1).

It also revealed that a significant 60% (Fig. 2) also used bleach for hand disinfection, due to a lack of commercially available alcohol-based hand sanitizing gels during this period. For fear of the severity of the coronavirus, the employees of the dairy industries in question preferred to use the two disinfectants studied, hydroalcoholic gel and bleach, as disinfectants are more powerful and quickly used than soap.

**Table 1** Analysis of MSDSs for disinfectants: bleach and hydroalcoholic gel

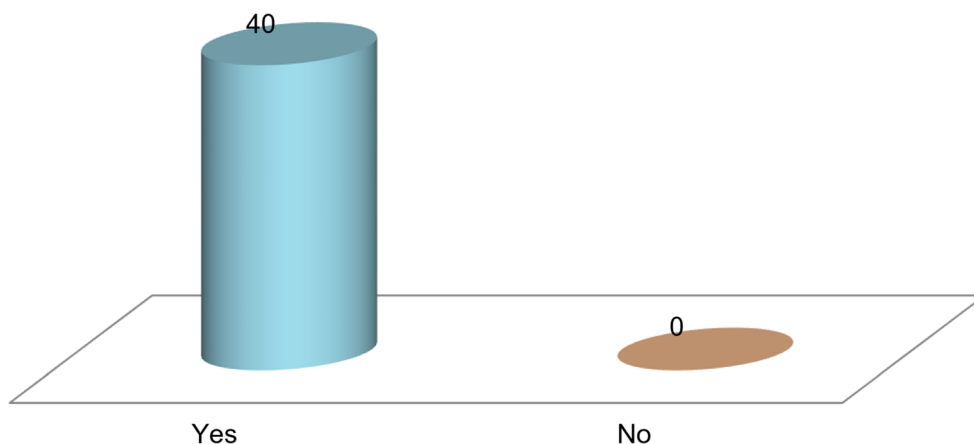
Disinfectant product	Principal symptoms and effects
<p>ACE—classic products for washing and cleaning Mixed: sodium hypochlorite, sodium carbonate, and sodium hydroxide Compliant with Regulation (EC) no. 1907/2006 (REACH) with its amendment Regulation (EU) 2015/830</p>	<ul style="list-style-type: none"> <li>▪ Principal symptoms and effects, severe and delayed symptoms/injuries after inhalation: coughing. Sneezing</li> <li>▪ Symptoms/injuries after contact with the skin: redness. Swelling. Dryness. Itching</li> <li>▪ Symptoms/injuries after eye contact: intense pain. Redness. Swelling. Blurred vision</li> <li>▪ Symptoms/injuries after ingestion: irritation of the oral or gastrointestinal mucous membranes. Nausea. Vomiting. Excessive secretion. Diarrhea</li> <li>▪ Causes skin irritation and severe eye irritation</li> </ul>
<p>Hydroalcoholic hand gel: biocidal product. Mixed: ethanol (700 mg/g or 755 ml/l—CAS No. 64-17-5) in the presence of thickening, moisturizing and emollient agents, and water. Without perfume or dye. Safety Data Sheet (Regulation (EC) no. 1907/2006 - REACH)</p>	<ul style="list-style-type: none"> <li>▪ Fire risk</li> <li>▪ Very large inhalation can cause nausea and irritation of the mucous membranes</li> <li>▪ The presentation of the product associated with its frequency of use can generate intolerance phenomena in reactive individuals</li> <li>▪ May cause reversible effects on the eyes, such as eye irritation which is fully reversible within a 21-day observation period</li> <li>▪ Splashes in the eyes can cause irritation and reversible damage</li> <li>▪ Serious eye damage/eye irritation: ethyl alcohol (CAS: 64-17-5) causes severe eye irritation</li> </ul>

However, the use of bleach is indicated only for disinfection and cleaning of surfaces according to the data presented on the MSDSs. This can certainly increase exposure to the health risks of this product and aggravate its effects on the health of employees, especially in the absence or inadequacy of collective and individual protective equipment.

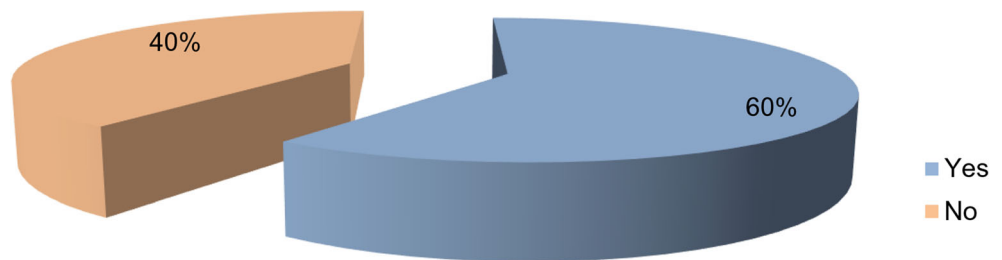
In the same sense, the assessment of the health and psychological effects caused by the use of the hydroalcoholic disinfectant for hand disinfection during the COVID-19 pandemic, for a period of 4 months, showed that this product caused serious health problems for its users. Out of 38 people who answered this question, 18 employees reported the appearance

of dermatological problems, and 4 people exposed to this risk reported the presence of psychological discomfort related to stress, fear, and discomfort. In addition to respiratory discomfort reported by 3 employees, 13 survey respondents reported the occurrence of other health problems (Fig. 3).

Compared to the use of bleach, 16 users of this product reported the appearance of dermatological problems (eczema, allergies...). Respiratory problems were also reported by 6 people, in addition to eye problems reported by 5 employees and two felt psychological discomfort: fear, stress, discomfort. Similarly, 12 employees reported other health effects caused by the disinfectant (Fig. 4).

**Fig. 1** Number of staff using alcohol-based hand sanitizers for hand disinfection during the COVID-19 pandemic

**Fig. 2** Percentage of staff using bleach for hand disinfection during the COVID-19 pandemic



These negative effects on people’s physical and psychological health can be increased, especially among people at risk such as the elderly and women, who represent 20% of those surveyed (Fig. 5).

The health consequences detected as a result of the use of these disinfectants are mainly explained by the failure to comply with the safety instructions indicated in the MSDSs, particularly the frequency of use, given that 93% of these people use these products several times a day, exceptionally during this pandemic, for fear of contaminating COVID-19 (Fig. 6).

A determining factor in occupational health safety is the adoption of individual and collective preventive measures during hand disinfection. Indeed, the survey showed that this factor is partially not adopted by the employees, which may increase the exposure to chemical risk, knowing that only 35% of the employees wear protective glasses, 62.5% use protective masks, and 27.5% wear safety gloves during the disinfection operation (Fig. 7). Compared to collective prevention, only 10% of employees disinfect their hands under the fume hood and 27.5% use these products in a ventilated space, and 25% of them reported not adopting any preventive measures (Fig. 7). This may be due to insufficient monitoring and follow-up actions and/or awareness sessions on the subject. In this study, we found that only 47.5% of the employees participating in the survey had received awareness and training sessions on the prevention of health risks related to the use of disinfectants (Fig. 7).

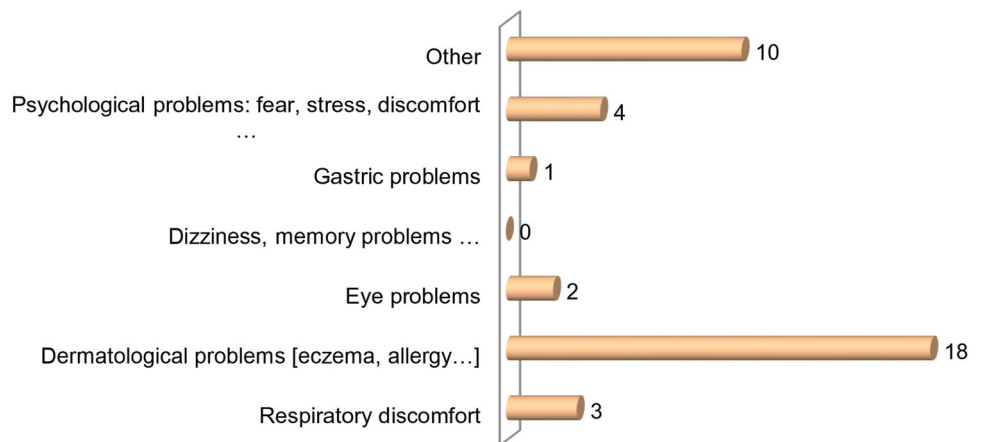
It therefore appears that this unforeseen and critical situation of the COVID-19 pandemic and the strengthening of

health security measures to fight against this virus has significantly provoked the emergence of a new risk that is not usually taken as an intolerable risk in the periodic occupational risk analysis in these companies. The emergence of this new risk may be due mainly to the inadequacy of the procedures for identifying and assessing these risks with the new pandemic situation. It may also be due to employee resistance to change caused by this health crisis and the failure to comply exactly with employment and safety instructions, which has led to unbalanced management of occupational risks in these workplaces.

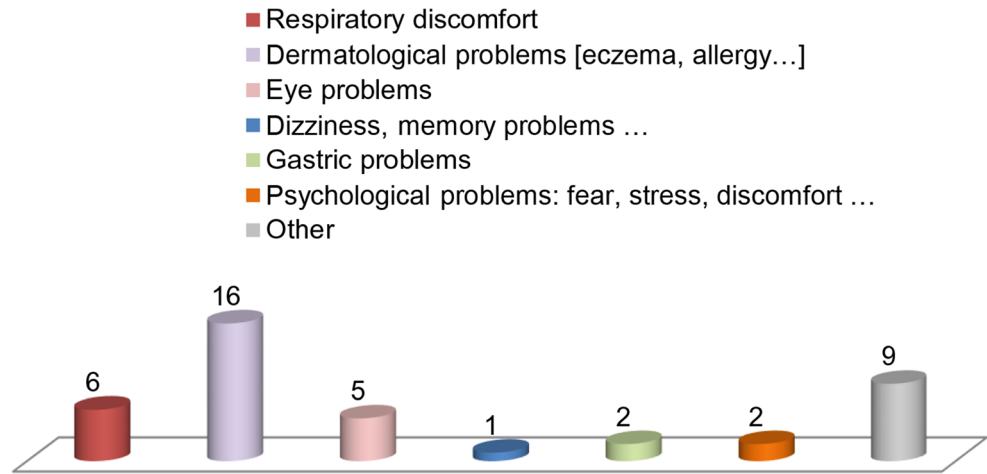
This new requirement would require a joint effort between company managers and employees to ensure a more secure workspace. Managers can reassess new occupational risks such as the chemical risk of the disinfectants used, which is the subject of our study, and strengthen prevention and continuous control actions, while emphasizing awareness, training, and support. It is the role of employees to apply and respect these safety instructions and to adapt to new working conditions.

Indeed, good occupational risk management requires the separation of functions in risk analysis activities if the risk assessment process is to retain its full scientific value and avoid pressures that would undermine the objectivity and credibility of the conclusions. However, frequent interaction between those responsible for risk management and those responsible for risk assessment within the company is essential for effective risk management decisions to be made (WHO 2002).

**Fig. 3** Assessment of the health and psychological problems caused by the use of hydroalcoholic disinfectants for hand disinfection during the COVID-19 pandemic



**Fig. 4** Appreciation of the health and psychological problems caused by the use of bleach for hand disinfection during the COVID-19 pandemic



In Morocco, a significant number of dairy firms have a HACCP quality assurance system for the management of food safety risks (Rachidi and Latrache 2020), including the dairy industries which are the subject of our study. In order to adapt to all these constraints in a concern of development and adaptation, it is essential to adopt an integrated risk management system, which is a voluntary approach undertaken by the management of the company which would group together the management of food quality and occupational safety in a single system. This allows productivity gains, optimization of resources (risk analysis, training of actors, management of indicators, management review, etc.), coherence (united and dependent systems), and reduction of the risk of conflicts in the management of the company and consequently enhancement of the company’s image (Mathieu et al. 2003).

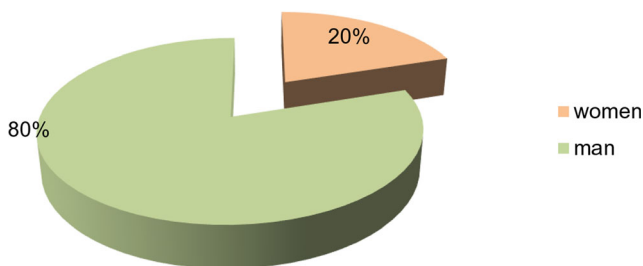
In the case of our study, we propose, then, to integrate the chemical risk management method into the HACCP system already installed in these companies. It is a question of adopting an approach that we have developed and proposed in a study published in 2016 (Rachidi et al. 2016a) with its example of application in an agro-food industry in Morocco (Rachidi et al. 2016b): it is the HACCP-OPERA approach. This new approach is a simplified method of assessment and management of chemical risk in the company; it brings together two approaches usually implemented separately: the HACCP approach and the OPERA method. This coupling of the two approaches makes it possible to integrate the

occupational health and safety management system into the internationally recognized HACCP system.

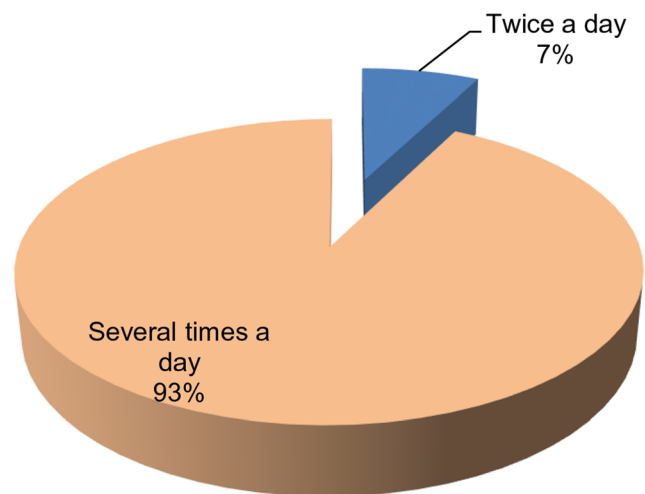
In effect, the adoption of the principles of the HACCP-OPERA approach for the analysis of the chemical risk related to the use of hand disinfectants during the COVID-19 pandemic in the dairy industries, the subject of our study, allowed us to identify chemicals labeled with safety data sheets and toxicological data sheets. These data were used to determine their hazards and potential harm, which we had already identified at the beginning of the study (see Table 1). The various information collected during the inventory will also be used to draw up safety data sheets at the workstations.

**Principle 1: Analysis of dangers and preventive measures**

According to the principles of the HACCP-OPERA approach, we evaluated the seriousness of the risks using the OPERA method based on the equation: Gravity of risk = [(A/B) + C]\*D

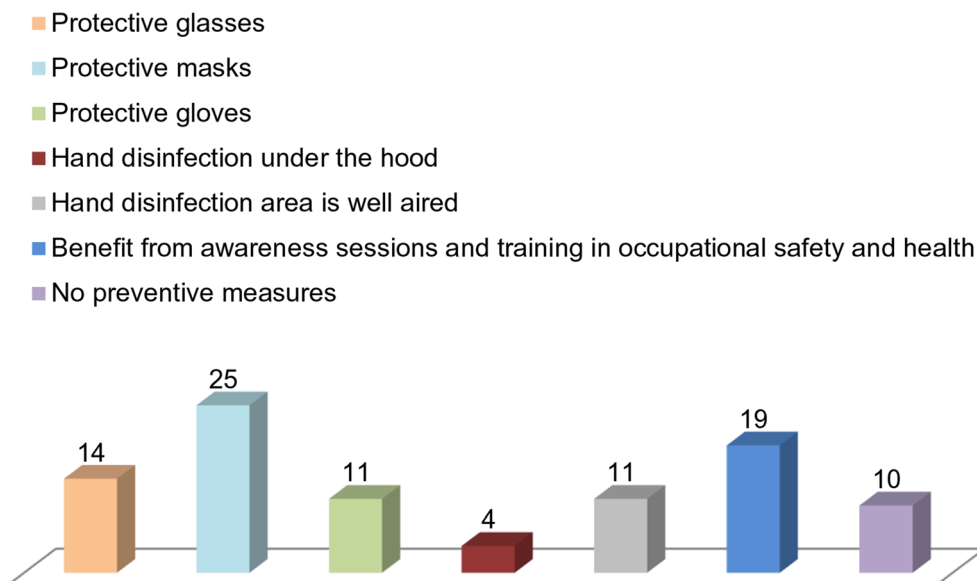


**Fig. 5** Employee survey participation rates by gender



**Fig. 6** Hand sanitizer usage rate for hand disinfection by day

**Fig. 7** Use of collective and personal protective equipment during hand disinfection



where *A*, *B*, and *C* are derived from the product label and MSDS and *D* is derived from the work process (Cram from Bourgogne Franche Comte 2008).

Knowing that the rating of factors *A*, *B*, *C*, and *D* is determined according to the following rules (Cram from Bourgogne Franche Comte 2008):

-*A*-factor rating: For every R-phrase (risk phrase), there is a rating from 3 to 10 [Quotation A [QA]] (see Table 2: R-phrase rating). The sum of all R-phrases gives the A-factor.

-*B*-factor rating: The *B*-factor represents the reduction of the *A*-factor, which can be obtained if all precautionary statements on the label or the safety data sheet (S-phrases) are respected.

\**B*= 2 when all precautionary statements (S-phrases) on the label or MSDS are complied with during the relevant operating phase,

\**B*= 1 when a single precautionary statement on the label or MSDS is not respected, or if there is no precautionary statement on the label or MSDS.

-Factor *C* rating: additional rating of certain R-phrases because of their hazardousness related to their carcinogenic, mutagenic, or reprotoxic (CMR) potential (see Table 2: R-phrase rating [Quotation C [QC]]).

-*D*-factor rating: the *D*-factor, rated from 0 to 5, depends on the presence or absence of the operator in the work area and the degree of dangerousness of the process used (see *D*-factor rating in Annex 1).

This assessment is based on the R-phrases which have become H-phrases according to the CLP Regulation (INRS 2020c) and the S-phrases which have also become P-phrases, which have a regulatory character. They appear on the labeling as well as on the safety data sheets of the chemicals used (Cram from Bourgogne Franche Comte 2008).

In the present study, we then evaluated the severity of risk of the two disinfectants (hydroalcoholic gel and bleach) used for hand disinfection, using the OPERA method, in the case of the use of preventive equipment by employees and in the opposite case (Table 3).

We note that the chemical risk caused by the use of bleach for hand disinfection is serious or imminent, even with the wearing of preventive equipment, due to the fact that this product is not indicated for personal use. In this case, it is essential to prohibit the use of this product for any personal use (Table 3).

Compared to the use of hydroalcoholic disinfectant for hand disinfection, the evaluation of this risk has shown that this product can be used in careful compliance with safety instructions, by adopting IPE (individual prevention equipment) and also strengthening collective prevention measures, particularly those related to the work environment, to reduce the severity of risk to an acceptable value (Table 3).

**Principle 2: Determination of critical control points for the control**

In order to control the level of safety concerning the use of the hydroalcoholic disinfectant for hand disinfection, and to guarantee a safe working environment, we propose to use the equation, *D* (critical point) = level of gravity of risk chosen / [(*A*/2) + *C*], from the HACCP-OPERA method to identify the critical points to be controlled (CP) and to determine the value of *D* corresponding to suitable working conditions.

We have chosen, in our case, the low risk level (15≥GR) (see Table 4) as the level at which the risk is not acceptable, with the understanding that the work team has the opportunity to choose the level of unacceptable risk appropriate to the specific characteristics of the institution and its activities.



**Table 2** R-phrase ratings (Cram from Bourgogne Franche Comte 2008)

Phrase R	QA	QC	Phrase R	QA	QC	Phrase R	QA	QC	Phrase R	QA	QC
1	10	30	8	14/15	9	39/28	8				
2	6	31	5	15/29	10	40/20					7
3	8	32	7	20/21	5	40/20/21					8
4	8	33	7	20/22	5	40/20/21/22					8
5	6	34	6	20/21/22	6	40/20/22					8
6	10	35	8	21/22	5	40/21					7
7	6	36	5	23/24	7	40/21/22					7
8	4	37	5	23/24/25	8	40/22					6
9	8	38	4	23/25	7	42/43				7	
10	4	39	8	24/25	7	48/20				6	
11	6	40		26/27	9	48/20/21				6	
12	8	41	7	26/27/28	10	48/20/21/22				7	
14	8	42	7	26/28	9	48/20/22				6	
15	8	43	7	27/28	9	48/21				6	
16	8	44	5	36/37	6	48/21/22				6	
17	10	45		36/37/38	7	48/22				6	
18	8	46		36/38	6	48/23				7	
19	6	48	6	37/38	6	48/23/24				7	
20	4	49		39/23	8	48/23/24/25				8	
21	4	60		39/23/24	8	48/23/25				7	
22	3	61		39/23/24/25	9	48/24				7	
23	6	62		39/23/25	8	48/24/25				7	
24	6	63		39/24	8	48/25				7	
25	6	64		39/24/25	8	68/20				7	
26	8	65	3	39/25	8	68/20/21				8	
27	8	66	4	39/26	8	68/20/21/22				8	
28	7	67	4	39/26/27	9	68/20/22				8	
29	6	68	6	39/26/27/28	10	68/21				7	
				39/26/28	9	68/21/22				7	
				39/27	8	68/22				6	
				39/27/28	9						

**Table 3** Severity of risk of disinfectants: hydroalcoholic gel and bleach

Product	R-phrases corresponding to H-phrases	Corresponding quotation of the R-phrases (see Table 2 of R rating)	Rating of A and C	Value of B	Value of D (see factor D rating in Annex 1)	Gravity of risk= [(A/B) + C]*D (see Table 4 of the level of risk according to its gravity)
Bleach water	H314 [R35], H315 [R38], H318 [R41], H319 [R36], H335 [R37]	R35= 8 R38= 4 R41= 7 R36= 5 R37= 5	In our case, all the quotations of the R-phrases correspond to the A-factor, so the C-factor is equal to 0	B= 1	The employee is entirely in the operating environment, so D is equal to 5	Gravity of risk = [(29/1) + 0]*5
				B= 2		Gravity of risk = [(29/2) + 0]*5
Hydroalcoholic disinfectant	H226 [R10], H319 [R36]	R10=4 R36=5		B= 1		Gravity of risk = [(9/1) + 0]*5
				B= 2		Gravity of risk = [(9/2) + 0]*5

**Table 4** Level of risk according to its gravity (Cram from Bourgogne Franche Comte 2008)

Gravity of risk: GR	Level of risk
< 5	Very low
5 < GR < 15	Low
15 < GR < 25	Medium
25 < GR < 35	Featured
35 < GR < 50	Very large
50 < GR < 70	Danger
> 70	Severe or imminent

At this stage of our HACCP-OPERA approach, the precautionary advice mentioned on the label or the safety data sheet are supposed to be respected; they are prerequisites of the approach, in this case ( $B=2$ ). The rating of factors  $A$  and  $C$  depends on the characteristics of the chemical product used. Consequently, it is on the basis of the GR and the factors  $A$ ,  $B$ , and  $C$  that one of the values of  $D$  (0, 1, 2, 3, 4, or 5) will be considered as the critical point to be controlled (see “scoring of factor  $D$ ” in Annex 1) (Rachidi et al. 2016a). The determination of the critical point for the use of the water-alcoholic disinfectant is as follows:  $D$  (critical point) =  $15 / [(A/2) + C]$ , with  $A=9$  [R-phrase scoring set] and  $C=0$  (see Table 2 for R-phrase).

So:  $D$  (critical point) =  $15 / [(9/2) + 0]=3.33$

In our case, we can choose more preventive working conditions, so the  $D$  (critical point) =3 (less than  $D$  (critical point) calculated =3.33) is the critical point to be mastered for the use of the hydroalcoholic hand disinfectant.

( $D=3$ : operator in the operating environment, local ventilation source capture type, open cabin (see factor  $D$  rating in the Annex 1)).

The value of factor  $D$  was fixed by the authors of the method on the basis of their experience. There is no need to modify them, as they are correlated with the relevance of the tool (Cram from Bourgogne Franche Comte 2008). Indeed, one of the values of  $D$  (0, 1, 2, 3, 4, or 5) will be considered as the critical point to be mastered (see “rating of the factor  $D$ ” in Annex 1).

**Principle 3: Determination of critical exposure limits for each critical point**

It is then a question of determining the critical limits of exposure to risk, knowing that the critical limits correspond to the extreme values acceptable in relation to operator safety. They set the acceptability or otherwise of the level of risk. These limits are usually determined by metrology and/or bio-metrology. In our present study, we propose a simple formula, from the HACCP-OPERA approach, to determine the critical limits

of each critical point, based on the equation:  $D$  (critical limit) =  $< \text{level of gravity of risk chosen} / [(A/2) + C]$  (Rachidi et al. 2016a).

In our case,  $D$  (critical limit) =  $< 15 / [(9/2) + 0]$ , therefore  $D$  (critical limit) =  $< 3.33$ , (with  $A=9$  rating set of R- and C-phrases=0 (see Table 2 of rating of R-phrases)).

Therefore, the acceptable  $D$  value for operator safety must be less or equal to 3.33. For more prevention, we can choose  $D=3$  (operator in the operating environment, local ventilation source capture type, open cabin...) as the critical limit not to be exceeded (see “ $D$  factor rating” in the Annex).

**Principle 4: Setting up a system for monitoring risk exposure for each CCP**

We also propose to adopt monitoring measures, following the principles of the HACCP-OPERA approach, such as continuous monitoring of working conditions and compliance with safety instructions, as well as the follow-up of awareness and training actions. These measures ensure, in particular, that critical limits are always respected and that they are also effectively controlled. They enable any deviation from the target values to be detected quickly.

**Principle 5: Establishment of a corrective action plan**

If the monitoring actions reveal that the critical limits are not well respected, that  $D$  (critical limit)  $> 3$  (change in working conditions), pre-established corrective actions must be taken.

**Principles 6 and 7: Application of the verification procedures and registration**

In addition, it is important to verify the correct application of the HACCP-OPERA procedures and to have a recording document that allows the data from the analysis of occupational hazards (accidents, incidents, and illnesses) to which workers are exposed to be gathered on a single medium. This provides a means of proof of the control exercised (Rachidi et al. 2016a).

**Conclusion**

Occupational risk evaluation, including chemical risk, is deeply concerned by the application of the precautionary principle. Our study provided risk managers in the dairy industry, particularly small and medium enterprises, with information and conclusions enabling them to reach more objective decisions on the most appropriate measures for operator health safety and prevention of the chemical risk associated with the use of hand sanitizers during the COVID-19 pandemic. This is to prohibit the use of bleach by employees for hand disinfection,

regardless of the preventive measures adopted. It is also a matter of using the hydroalcoholic gel with certain preventive measures and well-defined working conditions, based on the results of the application of the HACCP-OPERA method, which makes it possible to propose an integrated approach to the management of professional risks and food production.

This study can serve as a reference for companies to establish performance criteria and their prevention procedures for a balanced management of professional risks, and for public authorities to define standards. It would also allow employees to perceive the real risk incurred through effective and permanent communication.

### Some examples of *D*-factor scoring

*D*=0: absence of any operator in the environment.

*D*=1: physical separation between the operator and the operation ex:

Ventilated and closed fume cupboard.

Sealed machine without loss of product

Any device allowing the absence of total contact with the product.

*D*=2: human presence in the environment, not in the operating environment, depression-type

Ventilation

Ventilated paint booth, mostly outdoor operator

Ventilated but not closed fume cupboard

Evaporations less than one-third of the MEV (mean exposure value)

Inert gas that can reduce the concentration of oxygen (present for 5%) by 1 point.

*D*=3: operator in the operating environment, local ventilation source capture type, open cabin

Sprayed product

PE (flash point) higher than 20°C at room temperature

Operating temperature between 50 and 70°C

Atmospheric concentration (lower?) reaches the VME

Inert gas capable of lowering the concentration of oxygen (present for 10%) by 2 points.

*D*=4: operator entirely in the operating environment, general ventilation only

Sprayed product

PE above room temperature by 10° C only

Operating temperature between 70°C and 90°C

Atmospheric concentration reaches 2 TWA or TLV (threshold limit value)

Inert gas that can reduce the concentration of oxygen (present for 15%) by 3 points.

*D*=5: operator entirely in the operating room, manual operation, no ventilation

Product sprayed in the open air

PE less than or equal to the ambient temperature

Operating temperature greater than or equal to 90° C

Atmospheric concentration reaches 10 TWA or the ELV

Inert gas that can lower the concentration of oxygen (present for 20%) by 4 points or more.

### Questionnaire for employees in the dairy industries in Morocco concerning the use of hand disinfectants during the COVID-19 pandemic

1.Genre

- Woman
- Man

2.Do you use the hydroalcoholic hand sanitizer for hand disinfection during the COVID-19?

- Yes
- No

3.Do you use bleach for hand disinfection during the COVID-19 period?

- Yes
- No

4.How many times a day do you use these disinfectants?

- One time
- Twice
- Several times

5.Did you notice any health and psychological problems related to the use of the hydroalcoholic disinfectant for hand disinfection during the COVID-19 pandemic?

- Respiratory discomfort
- Dermatological problems [eczema, allergy...]
- Eye problems
- Dizziness, memory problems ...
- Gastric problems
- Psychological problems: fear, stress, discomfort ...
- Other

6.Did you notice any health and psychological problems related to the use of bleach for hand disinfection during the COVID-19 pandemic?

- Respiratory discomfort
- Dermatological problems [eczema, allergy...]
- Eye problems
- Dizziness, memory problems ...

- Gastric problems
- Psychological problems: fear, stress, discomfort ...
- Other

7. Have you adopted individual and/or collective preventive measures during hand disinfection with the two disinfectants used?

- Protective glasses
- Protective masks
- Protective gloves
- Hand disinfection under the hood
- Hand disinfection area is well aired
- Benefit from awareness sessions and training in occupational safety and health
- No preventive measures

**Acknowledgements** Warm thanks are given to everyone who participated in the realization of this work, especially Pr. Fatima Rachidi who participated in the correction of the article.

**Availability of data and materials** All data generated or analyzed during this study are included in this published article.

**Author's contribution** All the authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Rachidi H, Hamdaoui S, and Latrache H. The first draft of the manuscript was written by Rachidi H, and the translation of the article into English was carried out by Merimi I. The authors Bengourram J and Latrache H revised the content of the article, and Rachidi H corrected the article according to the comments and the requested changes. All the authors commented on previous versions of the manuscript. All the authors read and approved the final manuscript.

## Declarations

**Ethics approval and consent to participate** Not applicable

**Consent for publication** Not applicable

**Competing interests** The authors declare no competing interests.

## References

- Cereda DMT, Rovida FVD, MA Poletti P, et al. (2020) The early phase of the COVID-19 outbreak in Lombardy, Italy. ArXiv. 2020 Mar 20. Available from: <https://arxiv.org/abs/2003.09320>
- Chen T (2020) Reduce the transmission of COVID-19 by cleaning and disinfecting household surfaces. National Collaborating Center for Environmental Health (In french)
- Cram from Bourgogne Franche Comte (2008) Occupational risks, OPERA (In French) Available on: < <http://www.cram-bfc.fr/opera/page1.htm> >. Consulted the 18/07/2020
- Department of Surveillance and Risk Prevention, Ministry of Energy, Mines, Water and Environment. (2013) Morocco Guidelines for good practices in the sound management of chemicals in industrial settings (In French)
- European Agency for Safety and Health at Work (2020a). European directives on health and safety at work (In French) <https://osha.europa.eu/fr/legislation/directives/the-osh-framework-directive/the-osh-framework-directive-introduction>. Consulted the 18 August 2020
- European Agency for Safety and Health at Work (2020b) Exposure to chemical agents and chemical safety (In French). <https://osha.europa.eu/fr/legislation/directives/exposure-to-chemical-agents-and-chemical-safety/>. Consulted the 04 September 2020
- FAO / WHO (2020) COVID-19 and food safety: guidance for food businesses. Provisional guidance (In French)
- Guichard CH, Bordes JM, Karinthi Doyon A, Sauzedde F (2011) Simplified HRV methods: Hazard ratings of R phrases and H hazard statements according to CLP hazard classes and categories (In French) <http://revues.imist.ma/index.php?journal=morjchem&page=article&op=view&path%5B%5D=4803>
- INRS (2020a) COVID-19 and businesses. What are the risks of fire or explosion associated with the use of hydro-alcoholic gel? (In French) <http://www.inrs.fr/actualites/COVID-19-et-entreprises.html#a6f32e46-15f9-47f1-a4e0-dde8dbe57a6d>. Consulted the 01 September 2020
- INRS (2020b) Chemical hazards. Health and Safety Effects (In French) updated on 06/01/2020 <http://www.inrs.fr/risques/chimiques/effets-sante-securite.html>. Consulted the 01 September 2020
- INRS (2020c) Occupational safety and health. Understand the two chemical labeling systems (In French) updated on 06/01/2020. <http://www.inrs.fr/risques/classification-etiquetage-produits-chimiques/comprendre-systemes-etiquetage-produits-chimiques.html>. Consulted the 01 September 2020
- Liu J, Liao X, Qian S et al. (2020) Community transmission of severe acute respiratory syndrome corona virus 2, Shenzhen, China. Emerg Infect Dis 2020 [doi.org/10.3201/eid2606.200239](https://doi.org/10.3201/eid2606.200239)
- Mathieu S, Leveque L, Masse JP (2003) Self-diagnostic tools for the implementation of an integrated management: Quality - safety - Environment, Editions Afnor (In french)
- Official Bulletin N° 5210 OF MAY 6 (2004a) On the health and safety of employees, article 281, the new labor code, law n° 65.99 promulgated by the dahir n° 1.03.194 of September 11, 2003, 174 p (In french)
- Official Bulletin N° 5210 OF MAY 6 (2004b) On the health and safety of employees, article 287, the new labor code, law n° 65.99 promulgated by the dahir n° 1.03.194 of September 11, 2003, 174p (In french)
- Ong SW, Tan YK, Chia PY, Lee TH, Ng OT, Wong MS, et al. (2020) Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) from a symptomatic patient. JAMA 2020 Mar 4
- Qiu J (2020) Covert corona virus infections could be seeding new outbreaks. Nature 2020 (Mar 20). Available from: <https://www.nature.com/articles/d41586-020-00822-x>
- Rachidi H, Latrache H (2020) Preventive management of the risk of food borne illness in Morocco: Strategy and regulatory requirements. *Journal of Biomedical Research and Health Economics* N° 2. ISSN 2605-7549 (In french)
- Rachidi H, Bengourram J, Rachidi F, Latrache H (2012) Health risk analysis related to food poisoning in Morocco. *Microbiol. Hyg. Alim.-Vol 24*, N° 70
- Rachidi H, Bengourram J, Rachidi F, Mallouki B, Latrache H (2016a) Application of HACCP (Hazard Analysis Critical Control Point) system for the professional mastery of chemical risk to the operator. *Mor. J. Chem.* 4 N°2 613-628. <http://revues.imist.ma/index.php?journal=morjchem&page=article&op=view&path%5B%5D=4502>
- Rachidi H, Bengourram J, Rachidi F, Latrache H (2016b) Implementation of HACCP - OPERA approach to the assessment of chemical risks in a sugar factory in Morocco, based on the principles of HACCP - OPERA approach. *Mor. J. Chem.* 4 N°4 920-929

- Tixier G (2008). A point of view of the difficulties encountered in the use of HACCP. GRADA
- Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J (2012) Aerosol generating procedures and risk of transmission of acute respiratory infections to health care workers: A systematic review. *PLoS One* 7(4) <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3338532/>
- Van Doremalen N, Bushmaker T, Morris DH (2020) Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. DOI : <https://doi.org/10.1056/NEJMc2004973>
- WHO (2002) The interaction between those responsible for the assessment and management of microbiological risks in food. In: *FAO / WHO Global Forum of Food Safety Officials. For effective communication and interaction between risk assessors and food safety risk managers*, 28-30 January 2002, Marrakech (Morocco)
- WHO (2020) Critical preparedness, readiness and response actions for COVID-19: Interim guidance 19 March 2020. <https://www.who.int/publicationsdetail/critical-preparedness-readiness-and-responseactions-for-covid-19>
- Xiao F, Tang M, Zheng X, Liu Y, Li X, Shan H (2020) Evidence for gastrointestinal infection of SARS-CoV-2. *Gastroenterology* 2020 Mar 29. Available from: <https://doi.org/10.1053/j.gastro.2020.02.055>.

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.