Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Science & Justice 61 (2021) 735–742

Contents lists available at ScienceDirect

Science & Justice

journal homepage: www.elsevier.com/locate/scijus

Professional Practice Report

Interim recommendations for the management of forensic investigation during the COVID-19 pandemic: An Italian perspective

Enrico Di Luise [a,b], Paola A. Magni [c,d,*]

[a] Commander of Sezione Intervento Operativo (S.I.O.) – Arma Carabinieri, Reparto Carabinieri Investigazioni Scientifiche (R.I.S.), di Messina, Italy
[b] Laboratory of Forensic Biology, Arma Carabinieri, Reparto Carabinieri Investigazioni Scientifiche (R.I.S.), di Messina, Italy
[c] Discipline of Medical, Molecular & Forensic Sciences, Murdoch University, 90 South Street, Murdoch, Western Australia 6150, Australia
[d] Murdoch University Singapore, King's Centre, 390 Havelock Road, Singapore 169662, Singapore

ARTICLE INFO

Keywords:
SARS-CoV-2
Coronavirus
CSI
Procedure
Crime scene

ABSTRACT

The Coronavirus disease 2019 (COVID-19) is spreading around the world, representing a global pandemic. In this context, governments from around the world suspended almost all education, industry and business activities, alongside restricting the movement of people. Nevertheless, during this period, the activity of the law enforcement and forensic investigators never stopped.

At present, guidelines regarding forensic autopsies of SARS-CoV-2 virus-positive cases and the handling of potentially infected biological samples are available in literature. However, less attention has been given to the development of specific adjustments to the existing crime scene investigation protocols and procedures for this exceptional time.

This manuscript aims to share the methods and strategies adopted for the investigation of high priority criminal cases during the pandemic. Furthermore, other pandemic-related processes are critically explored, in order to propose adjustments for any forensic services to be prepared to face similar challenges in the future.

The overall goal of this manuscript is to provide a summary of the main measures and the procedures developed to make the operations possible, while safeguarding the technicians in the field and the activity in the forensic laboratory. In order to minimize the risk of infection for personnel, adjustments to the standard practice have been proposed for each of the different phases of crime scene management, i.e. CSI call policy, equipment preparation, working groups, procedure at the scene, chain of custody and analyses of the evidence at the forensic lab.

As this is a current study, based on limited cases and limited sources in the literature, changes and updates to the indications provided in this paper may be needed in the near future, according to new virological data epidemiological trends.

1. Introduction

The presence of coronavirus disease (COVID-19) in Italy was confirmed to have spread on January 31st 2020, when two Chinese tourists in Rome tested positive for the SARS-CoV-2 virus. Towards the end of February large clusters of cases were identified in the north of Italy, and by March cases were detected in every region of the Country [1].

As a consequence of the COVID-19 pandemic and similar to several other countries of the world, the Italian Government suspended all education activities, alongside every non-essential businesses and industries, and restricted the movement of people [2]. However, while during the peak of the pandemic Italy was recording one of the highest number of active cases in the world and more than 60 million Italians were forced to stay home, the activity of the law enforcement and the forensic investigators of the Italian military police (Arma dei Carabinieri) and non-military police (Polizia di Stato) never stopped. Governments and independent agencies agreed that despite the pandemic essential services must be guaranteed; thus, forensic and medico legal investigation should be performed when required by judicial authorities [3]. Instead, the issue of balancing the need for criminal investigation with the utmost priority of staff protection is still to be thoroughly debated [4].

Dealing with criminal cases in this unexpected situation was

* Corresponding author at: Murdoch University, 90 South Street, Murdoch, Western Australia 6150, Australia.
E-mail address: p.magni@murdoch.edu.au (P.A. Magni).

https://doi.org/10.1016/j.scijus.2021.08.002
Received 15 February 2021; Received in revised form 4 July 2021; Accepted 17 August 2021
Available online 19 August 2021
1355-0306/© 2021 The Chartered Society of Forensic Sciences. Published by Elsevier B.V. All rights reserved.

extremely challenging, because while the forensic practitioners were prepared for criminalistic tasks, there was an overall lack of development of standard operating procedures (SOP) to perform forensic investigations in such pandemic environment.

Over the years, major police institutions developed chemical, biological, radiological and nuclear (CBRN) protective procedures for crime scene investigation (CSI) activity, especially following terrorist attack concerns in the late 90′s and after the 9/11 World Trade Centre disaster. Crime scene processing that involves CBRN or other potentially hazardous materials requires the use of CBRN protective equipment and the application of special procedures to gather intelligence data as part of an investigation, while protecting operators from the exposure to potentially lethal agents. CBRN Units belonging to law enforcement and military corps around the world apply procedures and methodologies to assist forensic investigators and CSI teams, enabling the subsequent analysis of the evidence (contaminated with toxic/lethal agents) seized at the scene. Generally, different phases are included in these kinds of investigations: securing the scene (with appropriate safety perimeter), identification/quantification of the agent/s involved, scene processing (from documentation to forensic evidence collection, potential source of CBRN agents, decontamination and transport of evidences to the lab) [5–7]. These procedures can still be applied in case of an epidemic event caused by a highly contagious/deadly pathogen or in the early stages of an epidemic caused by an unknown/little known pathogen. However, in long term epidemic scenarios, such as the ongoing COVID-19 scenario, CBRN procedures could be considered disproportionate in relation to the operational time and cost that such measures imply. For example, the costs may be excessive and/or unaffordable by law enforcement for routine forensic activity, especially at a local/regional level, even in the event of a partial or total lockdown.

The need to develop specific adjustments to the existing procedures for this exceptional time was of pivotal importance to safeguard both the safety of the operators and the completeness of the forensic investigation, both during field operations and in the laboratory. To the best knowledge of the authors, recommendations, safety procedure and guidelines have been initially addressed for medico-legal laboratories [8] and law enforcement on ordinary duties [9], while there are currently none publicly available for crime scene investigation purposes.

Recently, the International Committee of the Red Cross (ICRC) stressed that staff safety and wellbeing must be the utmost priority of national authorities [3]. Within such frame, this paper aims to provide a summary of the main measures suggested and adopted by the authors in the management of the forensic investigation during the COVID-19 pandemic, listing the preventive actions and procedures developed to make the operations possible, while safeguarding the operators in the field. Furthermore, other pandemic-related processes are critically explored, in order to propose adjustments for any forensic services to be prepared to face similar challenges in the future.

In reading this paper it is essential to underline that currently the World Health Organization (WHO) and other Health/Governmental Agencies have yet to release official data on SARS-CoV-2 persistence on surfaces. However, recent research showed that such a virus can survive on certain materials for days (e.g. can be detected on copper for up to 4 h, cardboard for up to 1 day and on plastic and stainless steel for up to two to three days) [10–12]. Furthermore, the air persistence and related contagiousness of SARS-CoV-2 aerosol are currently under investigation [10–12]. For this reason, the protective measures here suggested and adopted are based on the present status of the research, the knowledge of other similar viruses, and the experience of other forensic services – especially in the medical and medico-legal practice – worldwide [8]. Specific personal protective equipment (PPE) and sanitizer/disinfectant solutions made available to the personnel are in accordance to the present knowledge of the current COVID-19 pandemic threat [13]; thus, changes and updates to the indications provided in this paper may be needed in the future, in accordance of new virological data and epidemiological trends.

Lastly, it is crucial to consider that similar to other coronaviruses, after leaving the host, SARS-CoV-2 can survive on the surface for a short period of time, although the rate of spread will slow down until it loses complete effect [10,14]. At the same time, the virus may remain active in deceased people that were infected with SARS-CoV-2, and the survival time of such viruses may be prolonged in refrigerated cadavers [15]. Recently some authors reported the detectability of SARS-CoV-2 up to 35 days after death [16]. Since not all the investigative operations are carried out immediately following a crime being committed, this aspect must be taken into consideration during the application of the suggested measures.

To note, the issues related to the need for SARS-CoV-2 test, isolation and monitoring for employees following on-duty activities [15,17] will not be discussed, as this is a broader topic regarding occupational safety, and would take away from the focus of this paper.

2. Intervention Level/CSI call policy

The ICRC recently published its recommendation for governments regarding the management of dead bodies and human remains, calling out public authorities in order to issue strategic plans and guidance for different scenarios [3]. In each country, policymakers are called to issue or modify the threshold of intervention, taking into consideration the type of criminal offense and the sanitary situation in the area. In a severe pandemic scenario, the emergency dispatch office and police operational centre must have clear guidance and criteria to accept or refuse a crime scene processing request.

During the peak of the COVID-19 pandemic outbreak in Europe, only investigations which were generally considered a “high priority”, (e.g. suspicious death, rape/abuse) were considered for compulsory attendance by the forensic team at the scene. In many cases, investigations concerning minor offences were instead assessed by the judicial authority for the absolute need for CSI activity and/or the chance for the CSI activity to be postponed without affecting the final outcome.

In most European countries law enforcement have not been offered official training specifically designed to assess the COVID-19 infection situation at the scene. Therefore, when a case is considered for investigative priority for the CSI team, the operations centre receiving the call should be trained to ask the requester to provide information about the health conditions of the victim(s) and/or the other people involved in the case, possible travel history in a pandemic area or the contact history of possibly infected people [18]. Such measure could dramatically improve preparedness and awareness of the team operating at the scene.

3. Working groups (CSI team)

Following the recommendations of labour and health institutions worldwide during the peak of the COVID-19 pandemic, employees in every field of public administration – also law enforcement and forensic experts of the Italian public sector – were separated and divided into working subgroups and regularly monitored [19,20]. Subgroups were not allowed to interact with people belonging to other subgroups within a given period of time, after which the shift could be modified, always fulfilling all of the traceability requirements. This presented in every labour field as a pure novelty due to the structure of each working group (i.e. teams or units) had to be adopted in accordance to the presence of the employees and the shift planning. The employee monitoring generally adopted consisted of body temperature check upon arrival at the work place and provided immediate notice of the coronavirus disease general symptoms (e.g. fever, cough, sore throat and headache) [21].

In the context of the COVID-19 pandemic, the director of the forensic service should be required to build the various CSI subgroups considering the necessity to maintain a certain independent forensic capacity within each of them. For example, each subgroup had to count on the presence of experts in at least areas of forensic biology, fingerprint

analysis and photography, with one of them also capable to undertake the task of team leader and sketcher/reporting officer. The above-mentioned adjustment is the only feasible way to manage a team with full operational ability and to safeguard the health requirements of personnel (i.e. redistribution in subgroups in order to minimise the contemporary presence of employees at the same place at a given time).

4. Equipment preparation and unit vehicles

4.1. Equipment preparation

Readiness and preparedness for the sudden occurrence of a crime scene investigation are critical aspects for all CSI Teams. In general, vehicles and equipment are cleaned and re-organized at the end of each fieldwork operation in order to be available at any time [22]. Prior to the COVID-19 pandemic, in order to speed and facilitate the task of cleaning and supplying the vehicles, forensic officers were assigned to work in small groups, wearing basic PPE. In the COVID-19 pandemic context, it was required that all the preliminary activities to field operation were to be performed individually, maintaining time/space separation or – if not possible – respecting social distancing between operators. Operators were required to wear full PPE (and in some cases full mask or similar respiratory devices) to protect against pathogenic infections. With regard to time separation for these activities, the criteria are indicated in section 7. In particular, if equipment/vehicle preparation is performed in a closed environment (i.e. small room/garage), an appropriate time separation between different operators' access, must be observed to allow air refreshing. Like other diseases, SARS-CoV-2 infection can be transmitted by a fomite (i.e. an inanimate material that can transfer the infectious agent to a new host). In fact, depending on the nature of the material, any forensic tool can act as a medium to propagate the infection to a certain extent; in other words, if contaminated at the scene, every utensil/object handled by a single operator can potentially propagate the infection to the rest of the CSI unit. Therefore, usage of the same item/apparatus by different technicians must be avoided from the outset. In order to assure operators safety, when feasible, the equipment should be prepared for use by a single person only. Tools like tool briefcases/boxes, UV/flashlights and PPE/reagents cases, were provided in replicates to be used by a single operator only. Further considerations regarding treatment to prevent fomites carryover are assessed hereafter, in following section 8. In addition to the standard equipment, basin/shoe washers with suitable solution aids (e.g. bleach and surface disinfectant) were included to be used when entering a highly contagious environment and to assist with circumstances when shoe covers may fail to prevent potential contamination. Note that similar equipment is currently used when inspecting areas subject to CBRN risk and/or for personnel deployment in contaminated areas. Lastly, each vehicle was also equipped with hand/skin sanitizer, surface sanitizer/disinfectant (for vehicle interior/various items), extra PPE supplies and PVC visors.

4.2. Unit vehicles

Country-by-country, regulation sets the minimum number of operators per vehicle. Generally, patrol cars require at least two officers on board when on duty and in operational mode, while logistic tasks may be carried out by a single person (as a driver). No PPE is required to be worn while in the vehicle.

During the COVID-19 pandemic it was required that an adjustment be made to the number of people, in order to have only the minimal number of personnel in each vehicle [23]. In addition to this, during transportation, individuals were required to sit as far as possible apart (e.g. two officers in two different rows, equally distributed front/rear seats), wearing gloves and face masks with at least FFP2 class of filter [24]. Upon arriving at the crime scene, operators must remove, discharge and wear new appropriate PPE before starting their investigative activities (see details about this in sections 6 and 8).

Furthermore, when vehicles return to headquarters at the end of the CSI activity, it is fundamental to maintain CSI unit readiness. During the COVID-19 pandemic this was achieved through adequate decontamination immediately or soon after vehicles returned without waiting days between the end of field operations and cleaning, as per the same policy/procedure adopted in hotel rooms after quarantine staying. The cleaning was performed using proper commercialized hygienic products for surface sterilization in health/hospital environments [25,26]. As briefly discussed in the previous section, the main difference in this case is that cleaners were required to wear both PPE and devices against pathogen infections.

5. PPE and safety of the operators at the scene

In order to improve safety, during the CSI activities, operators were recommended to wear both a mask with at least FFP2 (or N/KN95) filter and PVC visors in addition to the use of the usual PPE. This was particularly important while performing activities that required the simultaneous presence of two or more operators within close proximity. The use of other types of masks (e.g. FFP1 or surgical type) with no PVC visors has to be allowed only when a single operator is working at the scene and when there was no risk related to pathogen persistence in the air (e.g. In case of certainty of non-COVID-19-related casework; in case of a seized area where no individuals entered for days; in case of building not provided with central air conditioning systems). The use of masks provided with exhalation valve must be thoroughly assessed based on the investigation circumstances, as they are designed to filter the wearer's inhalation, not the exhalation. Since these masks provide protection from airborne pathogens only to those who are wearing it, they should be used only in particular circumstances (e.g. isolated/individual activities, prolonged/intensive activities). Generally, PVC visors can be re-used, but the decision of keeping such devices must rely on several factors like the distance maintained from potential source of infection during the activity, and the sterilization/sanitation capacity of the forensic department. In environments with high probability of SARS-CoV-2 contamination, operators were asked to clean their footwear in the shoe washers provided. Undergoing PPE dress up and removal, footwear wash and short operational breaks were set to happen in specific areas only (Fig. 1), with the recommendation of always maintaining social distancing between operators.

6. Procedure at the scene

Regardless to the scenario, CSI operators must consider every crime scene as an "hot zone" [4]. At present, the issue of the SARS-CoV-2 persistence and infectivity in the inanimate environment (including air and surface) is under research, and no robust data is so far available [24,27]. Nevertheless, limiting the number of operators simultaneously present in a room (or in a limited space) should be considered key, as recommended by Brazilian health official authorities for autopsy management [28].

At the beginning of the investigation, the initial walkthrough was recommended to be limited to a maximum number of two operators (note: in normal circumstances, the initial walkthrough can include more people if needed). Within the crime scene log access file, notes regarding the team members who had spent time without maintaining the statutory safe distance should be reported for infection traceability issues (e.g. initial walk through where the team leader and the prosecutor are close-by). Employing a minimal number of personnel and equipment, for each phase, while maintaining social distancing is key [29].

The initial crime scene area partitions should be clearly organized in order to avoid the operators to crossing paths. For example, designing a 'one way' (or 'single-channel closed-loop') path to enter, operate and exit from the crime scene [15] (Fig. 1). During the COVID-19 pandemic an additional 'clean area' was specifically designed, identified and

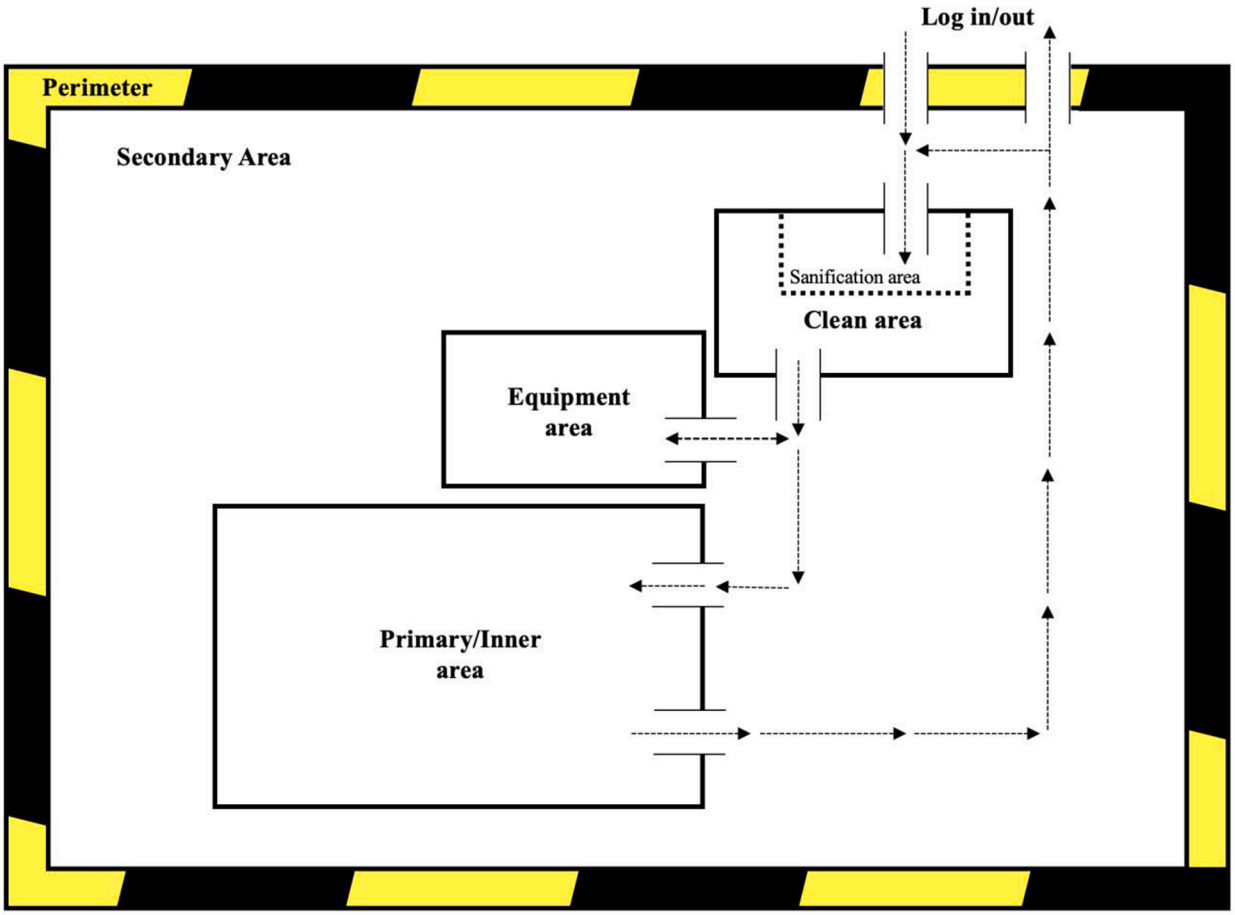

Fig. 1. General layout of proposed new distribution of crime scene investigative areas with directional pathways for movement of personnel while maintaining social distancing protocols. During the COVID-19 pandemic an additional 'clean area' is specifically designed. At the entrance of the 'clean area a *sanification* area allows personnel hygiene procedures, PPE dressing, cleaning and disinfection of the equipment. These operations must be completed immediately after entering, to don't contaminate the 'clean area'. Generally, the crime scene 'secondary area' is considered as semi-contaminated area where it is possible to perform auxiliary activities, while in the event of confirmed or suspected COVID-19 cases, the 'primary area' is instead considered a contaminated area.

located between the secondary zone and the outer zone (external perimeter). The 'clean area' is meant to be a buffer zone aimed to allow personnel hygiene procedures, PPE dressing, cleaning and disinfection of the equipment (to be stored in the equipment area at a later date), to be done immediately after entering. Generally, the crime scene 'secondary area' (normally designated for staging/equipment area) can be considered as semi-contaminated area where it is possible to perform auxiliary activities (i.e. disinfection of cases and packaging of evidence). Note that Prajapati and Kaursimilar indicated similar separation concepts intended for forensic laboratory workflow, in order to prevent Sars-Cov2 particle carryover and contagion [30]. In the event of confirmed or suspected COVID-19 cases, the 'primary area' of the crime scene was considered a contaminated area. In such cases, PPE undressing should be done within the secondary area, following the recommendations of the Centers for Disease Control and Prevention (CDC) and the European Centre for Disease Prevention and Control (ECDC) [31,32], while personnel hygienic procedures and dressing of new PPE before leaving the scene should be done in the secondary area.

When possible, during the investigation it was required to maintain safe distance between operators. The various investigative activities typically performed together (e.g. photography, biology, foot/fingerprints collection) were suggested to be performed at different times. For operations usually performed by two persons in a close range, whenever possible it was recommended the use of extensible supports to maintain interpersonal distancing, without affecting operational effectiveness and quality. For example, the use of an extensible stick when holding (UV) lights for searching or in performing macro photography.

In case of cadaver inspection during crime scene processing, application of specific medico-legal guidelines, carried out together with a certified coroner, are strictly recommended for corpse handling [14,17,19,29,33–35].

As discussed in section 4, the survival of the virus in the environment and its consequent infectivity is still under debate [12,36–38]. So far, available data are non-homogenous for the approach used in their experiments (aerosol viability, droplet decay, etc.). Nevertheless, considering the current publications, in a ventilated area the CSI team leader should reinforce a 20 min gap between the alternation of the activity of different operators at the scene [15,39,40]. In areas of poor ventilation instead, it must be considered that the aerosol stability of SARS-CoV-2 can persist for a few hours, ranging in half-lives between 1.1 and 1.2 h [12]. Observance of such timeframes should be maintained also during other activities, as discussed in chapter 4, and/or during the post-scene decontamination/cleaning of vehicles.

Collection of evidence regarding COVID19-related suspected or confirmed case, must be performed by using sealed air tight/leak proof container [30]. The latter indication has to be modified in case of fresh body fluids, in order to avoid the typical degradation of biological trace when sealed in plastic/non-transpiring bags. In case of fresh material, evidence at the lab will have to be immediately treated to allow drying, in a DNA-free flow cabinet, within a BLS3 grade facility. In any case, packaging should include proper label and warning signs indicating the potential risk of infection [20,30]. Avoiding and limiting any activity

with the potential of producing aerosol from any biological and physical evidence should be considered paramount [17,41]. In cases such when a hazardous scenario is inevitable, a portable fume extraction hood with a telescopic pipe can be regarded for on-the-scene usage. For evidence collection, the disinfection of the external surface of packages [8,15,42] could serve as an exceptional measure to minimize pathogens carried over from the scene to the CSI vehicle and eventually to the lab.

During following phases of treatment and transportation, materials should be considered as infectious.

7. Treatment of disposable materials used at the scene

During the CSI activity and at the end of it, all of the PPE and disposable materials used as equipment or tools at the scene, should be treated as medical waste as it may be potentially infected by the SARS-CoV-2 virus [27], regardless to the fact that they came in contact with any biological fluids.

At the crime scene, waste material was collected in special bags for hazardous/infectious material, outside the crime scene primary zone (mainly in the secondary/equipment area). Similar to the procedure followed prior to the pandemic, waste bags were then transported to the forensic police headquarters and subjected to incineration at certified waste disposal plants [34,43].

8. Treatment of non-disposable materials used at the scene

Reusable items and materials used during the investigation should be considered as primary fomites. Therefore, the personnel must be particularly careful in avoiding any transfer of contaminant pathogens from the scene to the headquarters and laboratory, carried over through the equipment.

During the COVID-19 pandemic, reusable tools were initially treated directly at the scene with disinfectants, denaturants or bleach, and sealed in proper non-transpiring bags and (eventually) collected in forensic boxes. The external surface of the boxes was also sanitized at the end of the CSI operation. This initial disinfection is to be performed in a specific area outside the primary perimeter, before entering the vehicle and leaving the scene. At the return to headquarters, every reusable item and apparatus (including the boxes that carried the tools cleaned at the scene) were sanitized (again) by mechanical/chemical disinfection and/or by thermal sterilization (e.g. via autoclave), performed in a dedicated room by staff members wearing PPE and devices against pathogen infections.

9. Transportation of evidence

In ordinary conditions, after proper collection and packaging, evidence transportation to forensic labs follow internal rules and procedures, concerning both chain of custody and, when needed, cold chain (for the latter, see 'storage consideration' below reported).

During the pandemic, fresh and semi-fresh body fluids (e.g. saliva) collected from the victim, the suspect and the scene must be considered potentially infected [44], and therefore transported only as "UN3373 Biological Substance Category B" [43,45] in appropriate conditions, both in terms of certified personnel and special vehicles.

Other forensic biological and non-biological samples/evidences (e.g. dry blood and touched objects for fingerprint, respectively) are yet to be reported as a highly contagious source of SARS-CoV-2 virus during transportation; thus, at the moment, after proper collection and packaging, these kinds of evidence should be transported simply in a safe condition, in a separated trunk or compartment [42,46]. Regardless, transportation documentation should include proper indication about the potential risk of infection [30].

Other types of ordinary evidence should be collected and stored separately, according to internal SOP.

10. Handling of samples for laboratory analysis

10.1. General

At present no research is available on the potential transmission of the coronavirus disease through physical evidence recovered from a (potentially infected) crime scene environment (e.g. clothes, touched objects, weapons). However, forensic laboratories should follow the WHO's recommendations to treat all samples as potentially infectious [35]. In the absence of any specific and detailed protocol, the general procedure is to treat any evidence with utmost care in order to prevent direct contact with the operator's body, especially with mucosae and open wounds due to accidental cuts during the operations [30,47].

Medical-case history must be handled, together with all the required documentation, at the case receiving office [30]. Such measure has to be upheld especially when evidence are submitted to the lab by different agencies and/or departments (i.e. evidence collected by CSI/ERT units not belonging to the same institution).

Even though a recent paper suggests the adoption of special measures for the collection of forensic biological specimen (e.g. use alcohol pre-moistened swab for biological specimen collection or heating the external surface of containers) [8,48], more scientific data are needed to formally apply changes to the current policies and procedures. Fresh and semi-fresh body fluids as biological samples collected from alive individuals and deceased bodies shouldn't be allowed into the forensic laboratory, unless classified as a BSL-2/BSL-3 facility [4,45]. Similar precautions should be applied for any physical evidence/object acting as fomite and/or for any procedure facilitating aerosol formation [17,41]. Alternatively, the collected evidence should be directed to a BSL-2/BSL-3 classified forensic laboratory or reduced at a non-propagative status (i.e. harmless and non-contagious) prior to being handled in the ordinary forensic biological laboratory [42]. In the latest case, proper labelling reporting the sample processing is required.

Whatever the BLS grade and the management policy of the lab is, a redesign of the examination and pre-treatment areas, providing space separation by including semi-contaminated, clean and buffer zones, is highly suggested [20,30]. Likewise other occupational environments, also in a laboratory, avoiding space sharing while preserving social distancing is of utmost importance to prevent infection.

10.2. Storage

Prior to the analytical phase, during storage time, potentially infected evidence should be separated from the ordinary ones and properly and clearly labelled as potentially SARS-CoV-2 infected. If needed, for these samples the cold chain should be maintained during the period of storage. Concerning the latter, it must be thoughtfully considered that whereas maintaining the cold chain could prevent aerosol formation/air resuspension from fomites, coronaviruses in general and SARS-CoV2 have undoubtedly shown increased persistence and infectivity at low temperatures [49,50] and lower resistance/infectivity at high temperature/high humidity conditions [24,51].

10.3. Analytical phase

All the analytical phases prior to DNA amplification (package opening, evidence inspection, presumptive/confirmatory testing, sample collection for DNA extraction) must be considered the riskiest. Hence, such operations should be performed following heightened safety measures (i.e. Biosafety Cabinet Grade II) or according to BLS2 laboratory requirements [4]. Even for possible future virus-airborne epidemic, further studies should assess the risk for lab technicians connected with potential RNA-coextraction during genotyping procedures.

Cotton swabbing with absorbent material and following drying, seems to be, at the current moment, the safest way to collect biological

samples [24]. Allowing complete drying of biological traces (e.g. blood/saliva/semen) and/or UV irradiation for non-biological trace could represent a promising approach to make such evidence harmless to operators [24]; nevertheless, it is still to be assessed by the scientific community and by the Public Health Agencies before being recommended as a method of choice. Other suggested procedures like sample UV irradiation and fume hood heat treatment [8] should be thoroughly evaluated for both sterilization efficiency and yield decrease in the downstream STR genotyping phase, especially for LT (Low Template) DNA trace.

Similarly, to crime scene operation in a non-pandemic scenario, aerosol-generating procedures (AGPs) activity should be avoided; when strictly necessary, portable laminar flow and fume hood extraction devices should be used in conjunction, for the safety of the operators.

10.4. Chain of custody

A correct chain of custody of the evidence is of pivotal importance for any forensic case [22]. The COVID-19 pandemic experience showed that almost in every occupational field an implementation of the traceability system is required.

In the COVID-19 scenario evidence collected from the same case, had different infection potential and as a consequence, were treated by different laboratories, different operators and after different time frames. In order to cope with this new situation, forensic laboratories should modify their traceability system in order to document in detail every evidence passage/analytical operation, specifying operator/time/place. Indeed, routine traceability recordings rarely include time and exact location (i.e. room) of the evidence transfer; in a pandemic scenario, it could be extremely useful to add this information in order to trace back the movement of potentially contaminated items and of the operating personnel within the forensic department.

Forensic departments should implement a reliable cleaning and disinfection plan to be applied in every zone concerned with the passage of any hazardous evidence [43,52].

Furthermore, it is crucial to prepare the forensic laboratories for the possibility of sudden episodes of elevated danger. In these cases, procedures should be put in place for the forensic department and laboratory workflow to be modified accordingly and in a prompt manner. Similarly to the WHO's recommendations for hospitals and clinical test centres, forensic labs should adopt their own "heightened control measures" and implement the internal risk assessment accordingly [30,45].

11. Final considerations

Crime scene investigation in a pandemic scenario like the recent COVID-19, pose a double-faced challenge: to assure law enforcement duties following criminal offenses and pursue occupational safety for forensic practitioners [18]. Currently no prediction can be made on the COVID-19 disease trend or on the advent of future similar airborne pandemics. However, it is most likely that in the near future the coexistence with COVID-19 and/or other similar pandemic threats will be a common issue to be faced. Due to the unpredictability and the ever changing characteristic of such threats, flexible structures and organization are to be implemented by governments and agencies in order to face future challenges [53].

CBRN investigation represents a major challenge for which many countries developed their highly specialized response units. Existing procedures for on-site investigation in the CBRN context represents the highest standards to maintain the safety of investigators and preserve the evidence, requiring skilled personnel and specific apparatus and equipment. CBRN procedures applied post-incident are generally more time-consuming and laborious than an ordinary CSI activity and are based on specific device, collection material and protective garment that generally differ from CSI tools and PPE [6,7]. Apart from the equipment requirements, aiming at different purpose (as like identifying a toxic warfare agent), CBRN scene management and investigation require many additional measures that can be considered unbearable for a CSI activity (for instance the presence of a backup safety team; the implementation different teams for different task such as evidence identification, sampling, etc.; presence of a safety officer, and a science officer cooperating with a scene coordinator; mandatory pre-entry briefing and risk assessment instead of a scene walkthrough, etc.) [7]. In addition, law enforcement agencies at a local scale are usually underfunded and/or underequipped to bear the cost of such personnel education and equipment maintenance and CBRN Units are not usually widely deployed in a given region. Moreover, during a COVID19-like pandemic, police departments (and the judicial authority) must fulfill their duties to identify, secure and provide relevant evidence in court, for various types of crime, within their jurisdiction, while pursuing several other tasks (i.e. crime prevention, public order etc.). During 2020, while lockdowns let minor offences' rate reduce (e.g. burglary and car theft), other crimes continued to persist in the face of a pandemic: serious crimes such as homicide and intimate relationship violence have stayed constant or increased [54]. Under these circumstances, mere application of a CBRN-based approach for any single case could therefore result in an expensive and cumbersome system, that would not cope with the real need in terms of intervention flexibility and efficiency. CBRN scene investigation measures as the "buddy system'' for crime scene processing, the multipart ''triage tag'' classification and the triple containment system for evidence collection [7], while perfectly coherent with safety issues, would result in a bulky burdening for an ordinary crime scene activity. Thus, the safety of investigators during crime scene processing can only be addressed through planning, personnel education and protocols adjustments, developed with regard to actual affordability.

Furthermore, while it is unlikely for a regional/local laboratory to reach those biological safety standards indicated for COVID-19 test laboratories [8,45], it is paramount to pursue analytical activities even in an epidemic scenario, thus maintaining operational efficiency and technicians care by any means, even within the forensic lab workflow.

So far, occupational risk analysis seems to agree in identifying workers employed in high contact job and in essential services (i.e. people working in healthcare, transportation, cleaning and store/supermarket, etc) as the most exposed to SARS-CoV-2 infection [55]. In general, the environment and the type of work (i.e.: number of people that a single employee meets during his/her shift in a close environment) is key in determining the risk factor connected with a certain job [55,56]. In comparison, police officers are less prone to be infected thanks to a lesser number of contacts with a potential host and to a more beneficial environment, with exception of particular cases as for example protest/riots control, prison guards, etc. In this sense, CSI units represent a unique structure as their members are forced occasionally to share closed space for a prolonged period of time. That said, currently there is no reliable data indicating significant contagion variances for each specific duty/task, nor in particular for the lab technicians [20], despite they are considered to be exposed to many bloodborne and airborne diseases by major public health organizations [30]. Due to the absence of the abovementioned data, or alternatively, of a baseline infection rate and/or of a control group for forensic personnel (i.e. infection data of CSI teams/units that operated during pandemic in an ordinary manner) it is very hard to clearly highlight the impact of the measures reported and suggested in this paper. Moreover, even in the case of a significantly higher or lower contagion rate in a single forensic department, other social variable factors such as total/local lockdown, personal habits, etc might have played a role in obtaining a given results. Further studies are therefore needed to reliably estimate the level of protection that these indications would provide to the operators. As a primary step, an appropriate study considering the comparison between the infection rate among a CSI team applying these measures and a CSI control group in an epidemic context - limiting the influence of variable factors - is needed to quantify the potential impact to officers' safety operating in a hazardous scenario. Furthermore, similar research could

be designed in a controlled environment mimicking the pandemic scenario, by using innocuous agents with SARS-CoV-2 -like activity and eventually testing all the operators involved for contagion/ and the equipment used for the presence of virus particle/droplets. Nevertheless, we firmly believe that the adoption of such measures can be tremendously significant for personnel safety, also in terms of individual confidence of any single technician processing the scene during a pandemic like the recent COVID-19 one. In fact a recent survey demonstrated that SARS-CoV-2 pandemic affected the mental condition of lab technicians in large percentages [20]. To the contrary, the absence of enhanced safety measures, issued and approved by the employers and/or LEA, can be perceived as a risky situation [30] and will eventually prevent operators from building up the necessary awareness to sustain the fulfillment of a technical task, in a stressful setting. Considering the similar recommendation issued for medico legal examiner during autopsies, the implementation of such measures can dramatically improve law enforcement agencies and the employer's capacity in terms of risk analysis and infection traceability.

Due to the effort necessary to implement similar adjustments, the observance of the protocols against pathogens carryover should be regularly re-assessed, both at a national and local level, by employers and lab directors, at the different stages of the pandemic. If the contagion curve drops down, then it would be possible to revert back to the ordinary protocols, with minimal effort. In case of rapid increase in the contagion trend, more stringent measures must be immediately applied; for this reason, an emergency plan clearly indicating the threshold level must be issued by health authorities in advance and be made available to anyone involved in the work chain.

In light of this, the main advantage of the majority of the measures proposed in this paper considers their feasibility – even at a local level – throughout internal protocols implementations and minimal efforts, leading to a favorable benefit/cost ratio. General policy criteria as like the one issued by the ICRC, regarding the Mass Fatality Response Plans (MFRP) in pandemic scenario [3] should be adopted and implemented by each national agency, while SOP and technical guidelines are meant to be released urgently by international governing bodies and then adopted by local forensic service. Meanwhile, local CSI Team Leader and Forensic Laboratory Directors should pursue personnel training and adopt internal procedures to avoid and reduce contagion risk at any cost.

12. Disclosure

The observation and the guidelines provided in this manuscript are based on authors point of view, based also on personal communications with other colleagues/institutions representative located worldwide, and not to be considered as formal procedures accepted and adopted by their Institutions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors thank Giancarlo Maugeri, Forensic Lab Technician at R. I.S. Carabinieri Messina for sharing his ideas throughout the drafting of this manuscript. Furthermore, we thank Louise Branch-Smith and Bevellee Partridge their useful comments and the English review.

References

[1] S. Ravizza, Coronavirus: First cases in Milan. What do we know about the new infections in Lombardy, Veneto and Piedmont [Italian], Corriere della Sera (2020).
[2] J. Crawford, K. Butler-Henderson, J. Rudolph, B. Malkawi, M. Glowatz, R. Burton, P.A. Magni, S. Lam, COVID-19: 20 countries' higher education intra-period digital pedagogy responses, J. Appl. Learn. Teach. 3 (2020) 1–20.
[3] O. Finegan, S. Fonseca, P. Guyomarc, M.D. Morcillo Mendez, J. Rodriguez Gonzalez, M. Tidball-Binz, K.A. Winter, I.A.G.o.t.M.o.C.-R. Fatalities, International Committee of the Red Cross (ICRC): General guidance for the management of the dead related to COVID-19, Forensic Sci. Int. 2 (2020) 129–137.
[4] M.C.A. De Ungria, Forensic DNA testing during the SARS-CoV-2 pandemic, Forensic Sci. Int. Genet. 40 (2020), 102346.
[5] N. Kummer, B. Augustyns, D. Van Rompaey, K. De Meulenaere, Forensic investigation of incidents involving chemical threat agent: Presentation of the operating procedure developed in Belgium for a field-exercise, Forensic Sci. Int. 299 (2019) 180–186.
[6] M. Kolencik, Crime Scene Investigation in a CBRN context, ISEM Institute (2021).
[7] S. Drielak, Hot zone forensics: chemical, biological, and radiological evidence collection, Charles C. Thomas Pub Ltd, Springfield, IL, USA, 2004.
[8] X. Yang, Q. Xu, H. Liu, J. Xu, D. Yang, C. xiao, H. Hu, Y. Liu, C. Liu, Collection and disinfection of forensic biological specimens in five cases concerning COVID-19 in Guangzhou, China, Forensic Sci. Int. 2 (2020) 210–214.
[9] Centers for Disease Control and Prevention (CDC), What law enforcement personnel need to know about Coronavirus Disease 2019 (COVID-19), Department of Health & Human Services, USA, (2020).
[10] F. Carraturo, C. Del Giudice, M. Morelli, V. Cerullo, G. Libralato, E. Galdiero, M. Guida, Persistence of SARS-CoV-2 in the environment and COVID-19 transmission risk from environmental matrices and surfaces, Environ. Pollut. 265 (2020) 115010, https://doi.org/10.1016/j.envpol.2020.115010.
[11] L. Fiorillo, G. Cervino, M. Matarese, C. D'Amico, G. Surace, V. Paduano, M. T. Fiorillo, A. Moschella, A. La Bruna, G.L. Romano, R. Laudicella, S. Baldari, M. Cicciù, COVID-19 Surface Persistence: A Recent Data Summary and Its Importance for Medical and Dental Settings, Int. J. Environ. Res. Public Health 17 (9) (2020) 3132, https://doi.org/10.3390/ijerph17093132.
[12] N. van Doremalen, T. Bushmaker, D.H. Morris, M.G. Holbrook, A. Gamble, B. N. Williamson, A. Tamin, J.L. Harcourt, N.J. Thornburg, S.I. Gerber, J.O. Lloyd-Smith, E. de Wit, V.J. Munster, Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1, N. Engl. J. Med. 382 (16) (2020) 1564–1567.
[13] G. Kampf, D. Todt, S. Pfaender, E. Steinmann, Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents, J. Hosp. Infect. 104 (3) (2020) 246–251.
[14] H.F. Rabenau, J. Cinatl, B. Morgenstern, G. Bauer, W. Preiser, H.W. Doerr, Stability and inactivation of SARS coronavirus, Med. Microbiol. Immunol. 194 (1-2) (2005) 1–6.
[15] D. Mao, N. Zhou, D. Zheng, J. Yue, Q. Zhao, B. Luo, D. Guan, Y. Zhou, B. Hu, J. Cheng, Guide to forensic pathology practice for death cases related to coronavirus disease 2019 (COVID-19) (Trial draft), Forensic. Sci. Res. 5 (2020) (2019) 1–7.
[16] P. Beltempo, S.M. Curti, R. Maserati, M. Gherardi, M. Castelli, M., Persistence of SARS-CoV-2 RNA in post-mortem swab 35 days after death: A case report, Forensic Sci. Int. 319 (2021) 110653, https://doi.org/10.1016/j.forsciint.2020.110653.
[17] R. Li, K. Yun, G. Yin, L. Li, Z. Liu, X. Zhang, P. Yan, T. Yang, Importance and guidelines of postmortem examination on COVID-19 cases: An overview, J. Forensic Sci. Med. 6 (3) (2020) 93, https://doi.org/10.4103/jfsm.jfsm_54_20.
[18] Y. Xue, L. Lai, C. Liu, Y. Niu, J. Zhao, Perspectives on the death investigation during the COVID-19 pandemic, Forensic Sci. Int. 2 (2020) 126–128.
[19] M. Halaji, A. Farahani, R. Ranjbar, M. Heiat, F.S. Dehkordi, Emerging coronaviruses: first SARS, second MERS and third SARS-CoV-2. Epidemiological updates of COVID-19, Le Infezioni, Medicina (2020) 6–17.
[20] M. Małecka, K. Ogrodzińska, G. Salczyńska, O. Ciepiela, Laboratory work safety rules and guidelines during COVID-19 pandemic in Polish clinical laboratories – do our laboratories work according to a recent IFCC Taskforce Recommendations? Clin. Chem. Lab. Med. 58 (2020) e205–e208.
[21] R. Chou, T. Dana, D.I. Buckley, S. Selph, R. Fu, A.M. Totten, Epidemiology of and Risk Factors for Coronavirus Infection in Health Care Workers: A Living Rapid Review, Ann. Intern. Med. 173 (2) (2020) 120–136.
[22] A. Mozayani, C. Noziglia (Eds.), The Forensic Laboratory Handbook Procedures and Practice, Humana Press, Totowa, NJ, 2011.
[23] H. Nishiura, H. Oshitani, T. Kobayashi, T. Saito, T. Sunagawa, T. Matsui, T. Wakita, M. Suzuki, Closed environments facilitate secondary transmission of coronavirus disease 2019 (COVID-19), medRxiv, (2020) 2020.2002.2028.20029272.
[24] S.-Y. Ren, W.-B. Wang, Y.-G. Hao, H.-R. Zhang, Z.-C. Wang, Y.-L. Chen, R.-D. Gao, Stability and infectivity of coronaviruses in inanimate environments, World J Clin Cases 8 (8) (2020) 1391–1399.
[25] Centers for Disease Control and Prevention (CDC), Cleaning and disinfection for households. Interim recommendations for U.S. households with suspected or confirmed coronavirus disease 2019 (COVID-19), in, 2020.
[26] European Centre for Disease Prevention and Control, Disinfection of environments in healthcare and non-healthcare settings potentially contaminated with SARS-CoV-2, in, 2020.
[27] S.W.X. Ong, Y.K. Tan, P.Y. Chia, T.H. Lee, O.T. Ng, M.S.Y. Wong, K. Marimuthu, Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient, JAMA 323 (2020) 1610–1612.
[28] M. Calmon, Considerations of coronavirus (COVID-19) impact and the management of the dead in Brazil, Forensic Sci Int. Reports 2 (2020) 100110, https://doi.org/10.1016/j.fsir.2020.100110.
[29] J.M. Lacy, E.G. Brooks, J. Akers, D. Armstrong, L. Decker, A. Gonzalez, W. Humphrey, R. Mayer, M. Miller, C. Perez, J.A.R. Arango, L. Sathyavagiswaran,

W. Stroh, S. Utley, COVID-19: Postmortem diagnostic and biosafety considerations, Am. J. Forensic Med. Pathol. 41 (3) (2020) 143–151.
[30] S. Prajapati, S. Kaur, Safety recommendations for forensic laboratory staff during COVID-19 pandemic, Academic Forensic Pathology (2021) 1–9.
[31] Centers for Disease Control and Prevention (CDC), Sequence for putting on personal protective equipment (PPE), in, 2020.
[32] European Centre for Disease Prevention and Control, Guidance for wearing and removing personal protective equipment in healthcare settings for the care of patients with suspected or confirmed COVID-19, in, 2020.
[33] European Centre for Disease Prevention and Control, Considerations related to the safe handling of bodies of deceased persons with suspected or confirmed COVID-19., in, 2020.
[34] J.Y. Na, S.J. Noh, M.S. Choi, J.P. Park, [Secondary Publication] Standard Operating Procedure for Post-mortem Inspection in a Focus on Coronavirus Disease-19: the Korean Society for Legal Medicine, J. Korean Med. Sci. 35 (2020), e302.
[35] World Health Organization, Infection prevention and control for the safe management of a dead body in the context of COVID-19: interim guidance World Health Organization, 2020.
[36] P.Y. Chia, K.K. Coleman, Y.K. Tan, S.W.X. Ong, M. Gum, S.K. Lau, X.F. Lim, A.S. Lim, S. Sutjipto, P.H. Lee, T.T. Son, B.E. Young, D.K. Milton, G.C. Gray, S. Schuster, T. Barkham, P.P. De, S. Vasoo, M. Chan, B.S.P. Ang, B.H. Tan, Y.S. Leo, O.T. Ng, M. S.Y. Wong, K. Marimuthu, T. Singapore Novel Coronavirus Outbreak Research, Detection of air and surface contamination by SARS-CoV-2 in hospital rooms of infected patients, Nat Commun, 11 (2020) 2800.
[37] A.C. Fears, W.B. Klimstra, P. Duprex, A. Hartman, S.C. Weaver, K.S. Plante, D. Mirchandani, J.A. Plante, P.V. Aguilar, D. Fernández, A. Nalca, A. Totura, D. Dyer, B. Kearney, M. Lackemeyer, J.K. Bohannon, R. Johnson, R.F. Garry, D. S. Reed, C.J. Roy, Persistence of severe acute respiratory syndrome Coronavirus 2 in aerosol suspensions, Emerg. Infect. Dis. 26 (9) (2020) 2168–2171.
[38] K. Nissen, J. Krambrich, D. Akaberi, T. Hoffman, J. Ling, Å. Lundkvist, L. Svensson, E. Salaneck, Long-distance airborne dispersal of SARS-CoV-2 in COVID-19 wards, Virol. Hospital Med. 10 (1) (2020), https://doi.org/10.1038/s41598-020-76442-2.
[39] G.A. Somsen, C. van Rijn, S. Kooij, R.A. Bem, D. Bonn, Small droplet aerosols in poorly ventilated spaces and SARS-CoV-2 transmission, The Lancet Respiratory Med. 8 (7) (2020) 658–659.
[40] V. Stadnytskyi, C.E. Bax, A. Bax, P. Anfinrud, The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission, Proc. Natl. Acad. Sci. U. S. A 117 (22) (2020) 11875–11877.
[41] K. Tran, K. Cimon, M. Severn, C.L. Pessoa-Silva, J. Conly, M.G. Semple, Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review, PLoS ONE 7 (4) (2012) e35797, https://doi.org/10.1371/journal.pone.0035797.
[42] M.Y. Kim, H. Cheong, H.S. Kim, C.-f.T.K.S.f.L.M. Working Group for Standard Autopsy Guideline for, Proposal of the autopsy guideline for infectious diseases: preparation for the post-COVID-19 era (abridged translation), J Korean Med Sci, 35 (2020) e310.
[43] Centers for Disease Control and Prevention (CDC), Interim laboratory biosafety guidelines for handling and processing specimens associated with Coronavirus disease 2019 (COVID-19), in, 2020.
[44] K.K. To, O.T. Tsang, C.C. Yip, K.H. Chan, T.C. Wu, J.M. Chan, W.S. Leung, T.S. Chik, C.Y. Choi, D.H. Kandamby, D.C. Lung, A.R. Tam, R.W. Poon, A.Y. Fung, I.F. Hung, V.C. Cheng, J.F. Chan, K.Y. Yuen, Consistent detection of 2019 Novel Coronavirus in saliva, Clin Infect Dis, 71 (2020) 841-843.
[45] World Health Organization, Laboratory biosafety guidance related to coronavirus disease (COVID-19), World Health Organization, 2020.
[46] Centers for Disease Control and Prevention (CDC), Collection and Submission of Postmortem Specimens from Deceased Persons with Known or Suspected COVID-19, in, 2020.
[47] C.W. Lu, X.F. Liu, Z.F. Jia, 2019-nCoV transmission through the ocular surface must not be ignored, The Lancet 395 (10224) (2020) e39, https://doi.org/10.1016/S0140-6736(20)30313-5.
[48] J. Biryukov, J.A. Boydston, R.A. Dunning, J.J. Yeager, S. Wood, A.L. Reese, A. Ferris, D. Miller, W. Weaver, N.E. Zeitouni, A. Phillips, D. Freeburger, I. Hooper, S. Ratnesar-Shumate, J. Yolitz, M. Krause, G. Williams, D.G. Dawson, A. Herzog, P. Dabisch, V. Wahl, M.C. Hevey, L.A. Altamura, Increasing temperature and relative humidity accelerates inactivation of SARS-CoV-2 on surfaces, mSphere, 5 (2020).
[49] H.A. Aboubakr, T.A. Sharafeldin, S.M. Goyal, Stability of SARS-CoV-2 and other coronaviruses in the environment and on common touch surfaces and the influence of climatic conditions: A review, Transbound Emerg Dis (2020).
[50] A.W.H. Chin, J.T.S. Chu, M.R.A. Perera, K.P.Y. Hui, H.-L. Yen, M.C.W. Chan, M. Peiris, L.L.M. Poon, Stability of SARS-CoV-2 in different environmental conditions, The Lancet Microbe 1 (2020).
[51] S. Riddell, S. Goldie, A. Hill, D. Eagles, T.W. Drew, The effect of temperature on persistence of SARS-CoV-2 on common surfaces, Virol J 17 (2020) 145.
[52] Q. Health, Interim infection prevention and control guidelines for the management of COVID-19 in healthcare settings, Queensland Government (2020).
[53] C. Roux, C. Weyermann, Can forensic science learn from the COVID-19 crisis? Forensic Sci. Int. 316 (2020), 110503.
[54] J.H. Boman, O. Gallupe, Has COVID-19 changed crime? Crime rates in the United States during the pandemic, American Journal of Criminal Justice, 45(4), 537–545., 45 (2020) 537-545.
[55] ECDC (European Centre for Disease Prevention and Control), COVID-19 clusters and outbreaks in occupational settings in the EU/EEA and the UK, (2020).
[56] Scientific Advisory Group for Emergencies. Managing infection risk in high contact occupations (2020).