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Forensic Science International: Genetics 48 (2020) 102346

Contents lists available at ScienceDirect

Forensic Science International: Genetics

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

Short communication

Forensic DNA testing during the SARS-CoV-2 pandemic

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ARTICLE INFO

Keywords:
SARS-CoV-2
COVID-19 pandemic
Biosafety
Forensic DNA testing
Criminal casework
Human identification

ABSTRACT

The aggressive nature of the new SARS-2 corona virus now referred to as SARS-CoV-2 ; the seriousness and length of the period of infection; the fast and far-reaching transmissibility via liquid droplets that become airborne when someone coughs, sneezes or speaks with increasing evidence to support actual airborne transmission; the presence of viral particles especially in body fluids and tissues, of viral positive individuals; and the persistence of the virus on different types of surfaces pose serious concerns for forensic practitioners, including forensic DNA analysts. Many forensic laboratories and law enforcement agencies need to address the inevitable changes that must be made in forensic DNA testing. In this article, we explore the effects of the COVID-19 pandemic on the collection, handling, storage and transport of biological samples for downstream DNA testing. This paper aims to open discussions on the urgency of balancing the need to conduct investigations in order to maintain public order with the requirements of effective biosafety protocols specifically formulated to protect human resources within the forensic science community.

1. Introduction

The aggressive nature of the new SARS-2 corona virus now referred to as SARS-CoV-2 [1]; the seriousness and length of the period of infection; the fast and far-reaching transmissibility via liquid droplets after someone coughs, sneezes or speaks with increasing evidence to support actual airborne transmission [2]; the presence of viral particles especially in body fluids and tissues of viral positive individuals; and the persistence of the virus on different types of surfaces pose serious concerns for forensic practitioners, including forensic DNA analysts. Many forensic laboratories and law enforcement agencies need to address the inevitable changes that must be made in forensic DNA testing that are conducted for crime scene investigations, medical examinations of victims of abuse particularly cases involving minors, post-autopsy identification of human remains, paternity/kinship testing, human DNA profiling, disaster victim identifications and expansion of convicted offender/arrestee databases during the pandemic. Because forensic DNA testing requires biological samples, all personnel involved in the process could potentially come into contact with human samples from SARS-CoV-2 positive individuals. After more than six months from learning about the existence of the virus, more reports reveal that one of the key factors in the epidemiological success of the SARS-CoV-2 compared to other known corona viruses is its ability to infect a person who could remain asymptomatic for 14 days or even longer, before symptoms of the disease are manifested [3]. How then would the possible presence of SARS-CoV-2 particles in crime scenes and asymptomatic persons affect the collection, handling, storage and transport of biological samples for downstream DNA testing? This paper aims to open discussions for law enforcement, forensic practitioners and universities that have forensic science programs, on issues concerning forensic DNA testing raised by the SARS-CoV-2 pandemic.

2. Collection and handling of biological samples

The potential exposure to infected biological samples from SARS-CoV-2 positive individuals, even if asymptomatic, is the most pressing concern for personnel tasked to collect samples for DNA testing from crime scenes. In principle, scene investigators are already protected if they follow the guidelines provided for by the Center for Disease Control and Prevention [4]. This includes the use of appropriate Personal Protective Equipment (PPE), e.g. mask/respirator, eye protection or face shield and clean long-sleeved gowns, the observance of personal hygiene and physical distancing of at least 6 feet. In the past, it had been challenging to get some investigators to be compliant in protecting themselves particularly when investigating crime scenes that are perceived to be 'safe'. During the present pandemic, CDC reminds law enforcement of the elevated risk of infection from direct contact with body fluids such as blood, phlegm and respiratory droplets [4]. Since the presence of SARS-CoV-2 in a crime scene may not be immediately apparent to the scene investigators, it has been recommended to treat every crime scene as a 'hot zone' [5]. Additionally, a laboratory study of the aerosol and surface stability of SARS-CoV-2 reported that the virus

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https://doi.org/10.1016/j.fsigen.2020.102346
Received 7 May 2020; Accepted 3 July 2020
Available online 10 July 2020

can last up to three hours in the air, four hours in copper surfaces, 24 h on cardboard and 2–3 days on plastic and stainless steel [6]. More recently, 239 experts have petitioned the World Health Organization (WHO) to declare that SARS-CoV-2 may spread indoors via small particles (less than 5 μm in diameter) that stay in the air for longer periods of time, or the so-called airborne transmission [2]. Hence, scene of the crime officers could be exposed to infective viral particles through many entry points for the entire duration of the scene investigation. Following the recommendation to consider all crime scenes as 'hot zones', crime scene officers must then follow the guidelines provided for by the WHO to treat all samples for laboratory analysis as potentially infectious [7]. Given these warnings, law enforcement is urged to review the effect of the heightened need to protect their human resources on the extent of crime scene investigation and information gathering that they are able to do during this pandemic.

Another area of great concern is the effect of the pandemic on the plight of abused women and children. During the quarantine period where persons are confined in small living environments with nowhere to go, there had been several reports of increased domestic and sexual violence [8]. Because of the 'stay at home' directives in many places/countries, a victim's access to resources may be reduced. Moreover, the compounded fear of going to hospitals and the realignment of health resources from general healthcare to the pandemic crisis have affected the number of reported cases of domestic violence and sexual assault [9]. Delays in reporting affect the recoverability of biological samples from the bodies of the victims that may contain the assailant's DNA because biological samples transferred via sexual contact can last only up to 72 h on the body of a child-patient [10].

The use of PPE may also introduce 'social barriers' between healthcare workers and child-victims during forensic examinations. The ability of the doctor to gain the trust of a child becomes more challenging during the pandemic because the patient could not see the doctor's face hidden behind a mask and PPE. How then can trained child specialists facilitate the interview and medical examination of a minor, some of whom may still be traumatized, whilst wearing their PPE? On the part of the health care worker, the need to collect buccal swabs for DNA testing to support allegations of oral sex as well as saliva that would be used to generate the victim's reference genotype also pose a great concern since the throat and sputum have been identified as primary compartments of SARS-CoV-2 replication [11]. The collection of oral samples would expose medical allied personnel to high risks of COVID-19 infection. In the Philippines, medical doctors of the Child Protection Network (CPN) have had to adjust their practices by including potentially infective zones in the general reception area, as well as the wearing of PPEs during medical examinations and sample collections using a sexual assault investigation kit. CPN is a network of hospitals in the Philippines that primarily examine and treat child victims of abuse. Notably, there had been reports of doctors in some hospitals who opted to print their photographs and stick these on their PPE to provide some sense of 'humanity' to patients undergoing examination and/or treatment [12]. Is this something that could be included in an amended protocol for medical examination of victims, particularly children, during this pandemic?

Recommendations for death investigations during the pandemic have also been made [13]. Given that death investigations must continue amidst the present crisis, the collection of biological material to help identify the dead, the adoption of additional protective measures during body [13] and dental [14] autopsies, as well as the management of the dead including those recovered in mass fatalities [15], are imperative. With the onset of thtyphoon season in Southeast Asia that normally last from June to November each year, countries like the Philippines need to already review their Mass Fatality Response Plan (MFRP) in light of the current crisis. Typhoons like Haiyan in 2013 displaced over 4.1 million people, resulted in more than 1800 missing and 6000 deaths, many of whom remain unidentified until today [16]. The work of identifying mass fatalities poses a great concern due to the high numbers of individuals involved, co-mingling of bodies, and exposure of human remains to different surfaces and conditions which may have persistent SARS-CoV-2 particles. Field set-ups in many of these types of investigations typically lack even in the most basic requirements such as accessible roads, running water, electricity, working areas and storage facilities, and 'sleeping/living' quarters for responders thus making it difficult for personnel to fully comply with WHO/CDC/ICRC requirements for personal hygiene, use of proper protective equipment, frequent decontamination of work areas and physical distancing. The use of a bone saw to collect hard bone samples following INTERPOL guidelines for DNA testing will generate pulverized particles that can increase the likelihood of persons inhaling infective particles [17,18]. In addition, reference samples from relatives of the deceased usually consist of buccal swabs or saliva which increases the likelihood of SARS-CoV-2 transmission from asymptomatic family members to the medical team, and vice versa. The need for families to identify their kin as part of the post-disaster recovery process is recognized. However, given the SARS-CoV-2 pandemic, the need for identification must be balanced with the value of protecting lives, all of which must be contained in the MFRP specific for each country or locality.

3. Laboratory processing of nucleic acid material

WHO recommends that during the pandemic, personnel must treat all samples for laboratory analysis as potentially infectious [7]. Following this assumption, all forensic DNA laboratories that are processing biological samples collected from the time of entry of the SARS-CoV-2 virus into their country to the present, must be at least working in a Biosafety Level 2 (BSL-2) laboratory and all personnel must treat their work as high risk [19]. With increasing evidence of the airborne transmission of the virus, the use of an enhanced Biosafety Cabinet II inside the BSL-2 laboratory has become imperative.

There are numerous procedures for pre-processing and extracting DNA from different types of biological samples, e.g. body fluids, bones, teeth, and tissues of different states of decomposition/preservation, in liquid or solid substrate, e.g. those transferred onto FTA™ cards and similar paper-based material. WHO recommends the compartmentalization of the laboratories such that BSL2 requirements apply for work involving infectious materials [20]. This would include the initial opening of the package containing biological samples, pre-processing of tissues and DNA extraction steps, all of which must be conducted in an enhanced Biosafety cabinet II [21]. Excess unprocessed biological material e.g. body swabs, saliva, blood and other body fluid, bone, teeth and tissue samples, must be stored as potentially infectious material. Further, the viability of infective SARS-CoV-2 on FTA™ and similar solid substrates deserves attention. Prior to the pandemic, DNA on FTA™ and similar solid substrates were handled on standard open laboratory benches without the use of special containment equipment. However, because the virus was detected up to 24 h on cardboard [6], should samples on FTA™ and similar solid substrates be left inside the BSL2 biosafety cabinet for at least 24 h before these cards are moved to an open bench, if at all? Theoretically, once DNA is extracted and biological waste is properly disposed following BSL-2 protocols, downstream molecular analysis of nucleic acid preparations, such as PCR amplification, genome library preparation, DNA fragment analysis and sequencing can be performed outside of a BSL-2 safety cabinet [19]. However, is there a need to validate different DNA extraction protocols to ensure that SARS-CoV-2 which is an RNA virus [1] does not co-extract with the DNA and remain infectious at any stage of the extraction and post-extraction procedures?

The requirement to set-up a BSL2 laboratory with an enhanced Biosafety Cabinet II will be challenging for many forensic DNA laboratories and universities that offer forensic science programs particularly in countries or regions with limited resources and infrastructure. The high number of samples collected in a crime scene investigation or post-disaster makes this requirement almost

impractical. Hence the US Occupational Health and Safety Administration recommended preliminary site-specific assessments to determine if protocols used are sufficient for the type of testing being conducted in these laboratories [19].

4. Management of forensic DNA databases

Routinely, DNA samples are stored post-analysis as part of a DNA database or as evidence following laws or policies of the country, or state [22,23]. Given the human to human transmission of the SARS-CoV-2, people responsible for the routine collection of saliva samples from arrestees and convicted offenders must also follow all precautionary procedures in the handling of biological samples. In fact, the CDC has recommended guidelines to law enforcement officers starting from the arrest and transport of persons from a scene or locality [4] through to the handling of biological samples [21] needed to generate a reference genotype that would be used in searching criminal databases such as CODIS.

The contribution of forensic DNA testing in identifying those involved in crimes and excluding those who were misidentified takes paramount importance at this time. In countries like the Philippines were prison congestion rate is as high as 534 % and where recent data showed that there are 215,000 people held in facilities intended to house only 41,000 persons, most of them awaiting trial, overcrowded prisons have become pandemic time-bombs ready to explode [24]. This phenomenon is shared across countries like Brazil and Columbia [25]. In the US, deaths of members of the Navajo Nation that were connected to prisons have been reported [26]. Can law enforcement agencies with forensic DNA testing laboratories formulate DNA testing strategies to accelerate the release of persons excluded by virtue of DNA testing, amidst delays in court litigations, during the pandemic?

In addition, most forensic DNA laboratories manage volunteer DNA databases for research into new forensic DNA markers and genetic variations in different populations. Many of the reported DNA databases are concentrated in Europe, the US, Canada, Australia, New Zealand, South Korea, Singapore, Japan, Malaysia and China, because of the amount of funding needed to establish, maintain, and expand these DNA databases. DNA analysts recognize the need to adopt an inclusive strategy and increase the representation of other populations in globally shared DNA databases in order to reduce sampling bias and strengthen the identification capacities of DNA tests. However, new collection of saliva and/or blood samples during the pandemic may have to be temporarily discontinued because of travel restrictions, limited government and institutional resources that have been diverted towards SARS-CoV-2 cases, and protection of healthcare workers who would be exposed to potentially infectious samples from volunteers, some of whom may be asymptomatic for COVID-19. Moreover, DNA analysts involved in forensic research may have to explore alternative sample sources, such as existing biobanks, and to submit the appropriate ethics application that are required to access these resources. Would ethics review committees consider the complexity of the current crisis to consider “a waiver of consent” application and allow the use of archived anonymized samples for forensic genetics research?

5. Conclusions

The recommendations for the strict compliance in using PPEs for crime scene investigators, healthcare workers and laboratory personnel as well as the required infrastructure for BSL2 laboratories entail additional costs for law enforcement agencies and forensic institutions at a time when resources are limited. Increasing the BSL level of existing laboratories and universities would also involve training of personnel in biosafety practices, and modification of previous protocols to accommodate the use of biosafety cabinets and other instruments for handling potentially hazardous biological samples. Additionally, the global supply of PPEs is limited [27]. Hence, law enforcement agencies and forensic institutions must plan the most effective use and allocation of these resources in forensic investigations and DNA testing.

Meanwhile, the pandemic has severely crippled the economy and many countries are bracing themselves for a global economic recession that is greater than what any state has experienced in recent years. The lockdown has temporarily slowed down criminal activities but it has also allowed criminal groups to regroup and exploit the uncertainties brought about by the pandemic [28]. Europol has released a report on its projections on serious and organized crimes during and after the SARS-CoV-2 pandemic [29]. Given these considerations, law enforcement agencies and forensic institutions must balance the need to continuously conduct investigations in order to maintain public order, with the biosafety requirements of protecting their human resources and the general public. This balance can only be achieved with the support of the national government, ample multilateral collaborations amongst government agencies and private institutions, careful planning by institutional administrators, technical input from experienced forensic practitioners, and full compliance by all personnel with biosafety guidelines provided for by internationally recognized health institutions.

Acknowledgments

The author acknowledges Jose Manguera Jose, LLB for interesting discussions about the paper and for his assistance in revising the manuscript.

References

[1] Coronaviridae Study Group of the International Committee on Taxonomy of Viruses, The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2, Nat. Microbiol. 5 (4) (2020) 536–544.
[2] A. Mandavilli, 239 experts with one big claim: the Coronavirus is airborne, The New York Times, (2020) New York.
[3] D.P. Oran, E.J. Topol, Prevalence of asymptomatic SARS-CoV-2 infection, Ann. Intern. Med. (2020).
[4] CDC, What Law Enforcement Personnel Need to Know About Coronavirus Disease 2019 (COVID-19), Center for Disease Control and Prevention, 2020.
[5] Z. Kowalske, Crime scene investigations during COVID-19, Forensic Magazine, (2020).
[6] N. Van Doremalen, et al., Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1, N. Engl. J. Med. 382 (16) (2020) 1564–1567.
[7] WHO, Infection Prevention and Control during Health Care When COVID-19 Is Suspected, World Health Organization, 2020.
[8] M.A. Onyango, Sexual and gender-based violence during COVID-19: lessons from Ebola, The Conversation, (2020).
[9] M. Reynolds, How COVID-19 Pandemic Creates Obstacles for Sexual Assault Survivors, American Bar Association, 2020.
[10] S.M. Maiquilla, et al., Y-STR DNA analysis of 154 female child sexual assault cases in the Philippines, Int. J. Legal Med. 125 (6) (2011) 817–824.
[11] WHO, A Coordinated Global Research Map, World Health Organization, 2020, pp. 1–96.
[12] T. Lakritz, Healthcare Workers Are Taping Photos of Themselves to Their Protective Gear to Help Put COVID-19 Patients at Ease, (2020).
[13] Y. Xue, et al., Perspectives on the death investigation during the COVID-19 pandemic, Forensic Sci. Int. Synergy 2 (2020) 126–128.
[14] E. Nuzzolese, H. Pandey, F. Lupariello, Dental autopsy recommendations in SARS-CoV-2 infected cases, Forensic Sci. Int. Synergy (2020).
[15] O. Finegan, et al., International committee of the red cross (ICRC): general guidance for the management of the dead related to COVID-19, Forensic Sci. Int. Synergy (2020).
[16] World Vision, Typhoon Haiyan: Facts, FAQs and How to Help. 2020, World Vision, 2013.
[17] Interpol, DVI Guide, (2009), pp. 1–55.
[18] ICMP, Standard Operating Procedure for Sampling Bone and Tooth Specimens from Human Remains for DNA Testing at the ICMP, International Commission on Missing Persons, Sarajevo, 2015, pp. 1–19.
[19] Occupational Health and Safety Administration, COVID19 Control and Prevention: Laboratory Workers and Employers, (2020).
[20] WHO, Laboratory Biosafety Guidance related to the Novel Coronavirus (2019-nCoV), World Health Organization, 2020.
[21] CDC, D.E. Wilson, L.C. Chosewood (Eds.), Biosafety in Microbiological and Biomedical Laboratories, 5th ed., Center for Disease Control and Prevention, 2009US Department of Health and Human Services.
[22] A.O. Amankwaa, C. McCartney, The effectiveness of the UK national DNA database, Forensic Sci. Int. Synergy 1 (2019) 45–55.

[23] T.R. Moretti, et al., Population data on the expanded CODIS core STR loci for eleven populations of significance for forensic DNA analyses in the United States, Forensic Sci. Int. Genet. 25 (2016) 175–181.
[24] A.P. Santos, 'Waiting to Die': Coronavirus Enters Congested Philippine Jails, in Aljazeera, (2020).
[25] World Prison Brief, Highest to Lowest - Occupancy Level (based on Official Capacity), Available from: (2020) https://www.prisonstudies.org/highest-to-lowest/occupancy-level?field_region_taxonomy_tid=All.
[26] V. Jones, 10 Steps to Save Native Americans from Covid-19 Catastrophe, (2020).
[27] WHO, Rational Use of Personal Protective Equipment (PPE) for Coronavirus Disease (COVID-19), World Health Organization, 2020.
[28] Global Initiative Against Transnational Organized Crime, Crime and Contagion: The Impact of Pandemic on Organized Crime, (2020), pp. 1–25 Geneva, Switzerland.
[29] Europol, Beyond the Pandemic How COVID-19 Will Shape the Serious and Organised Crime Landscape in the EU, European Union Agency for Law Enforcement Cooperation 2020, 2020.