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.

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Short Communication

Can forensic science learn from the COVID-19 crisis?

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ABSTRACT

This paper draws parallels between the current COVID-19 crisis and the apparent forensic science crisis. It investigates if shared approaches of the problem and solutions could emerge. Some relevant aspects of the medical system as it reacted to the pandemic crisis and the situation in forensic science are presented. Further, three main stages of the COVID-19 crisis and its impact on individuals and society are proposed, highlighting similarities to the effects of forensic science. Finally, some lessons from COVID-19 for forensic science are identified and discussed. It is concluded that forensic science's best assurance to address current and future challenges, particularly in an increasingly digital environment, remains a sound scientific approach, including critical thinking and inter-disciplinary collaborations.

Forensic science has been portrayed as being in crisis for approximately twenty years. The primary catalyst of this apparent crisis, at least initially, can undoubtedly be traced back to the loosely defined 'laboratory backlog'. In the nineties and first half of the noughties, forensic science laboratories were overwhelmed with cases due to technology developments generating demand for significantly more laboratory testing, particularly DNA analysis. This situation rapidly led to increasing backlogs, in turn, reducing or slowing down the apparent impact of forensic science on the justice system [1]. One conventional solution to address this 'crisis' was to increase resources and technologies and modify processes to speed up the testing (in a case-by-case approach). For example, improvement included the introduction of DNA collection kits ready for robotic systems in the laboratory. There were fewer considerations for prioritising the analysis through triaging cases, substrates and contexts (in a multi-case approach) that would lead to the most significant impact. However, the primary outcome was met: today, DNA backlogs have been significantly reduced, if not disappeared.

Twenty years later, the forensic science community is again facing similar issues with the rapid digital transformation of society, and technology solutions are yet being suggested (e.g. extracting and triaging big data through artificial intelligence). More generally, talks about a forensic science crisis are still very present, and it seems that any proposed way forward invariably leads us to the same intractable crossroads [2]. At a time when society is facing another much more significant and immediate global crisis with COVID-19, we feel that this is an opportunity to draw parallels and investigate if shared approaches of the problem and solutions might emerge. In other words, can forensic science learn from the COVID-19 crisis? To answer this question, first, we will compare some relevant aspects of the medical system as it reacted to the pandemic crisis and the situation in forensic science. Then we will uncover the main stages of the COVID-19 crisis and its impact on individuals and society, highlighting similarities with the (actual or aspired) impact of forensic science. Finally, we will identify what the main lessons from COVID-19 could be for forensic science.

1. Medicine and forensic science as analogous sciences[1]

Forensic science like medicine is a historical science [2,3], and both share a 'diagnostic' methodological approach [3]. While medicine focuses on the study of *symptoms* to investigate *diseases* (or abnormal conditions affecting the functioning of the human body), forensic science studies *traces* to investigate *crimes* (or

[1] It is recognised that many differences also exist between forensic science and medicine, e.g. in operations or in terms of education models and fundamental principles that are respectively more uniform and more generally accepted in the medical than in the forensic science space. The description of these differences is beyond the scope of this paper and will be presented in a future work.

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deviant behaviours harmful to society).[2] Both sciences help to answer the same type of questions such as "what caused the disease/death of a person?" (for example) or "when and how did the disease/crime occur?". As seen during the COVID-19 pandemic, reconstruction can also be necessary in medicine, as it is in forensic science. For example, when a patient is tested positive to COVID-19, it is crucial to reconstruct their past activities through 'interrogation' to isolate people that were in close contact with them or visited the same locations.[3] The parallel can be drawn with the quick arrest of a person (or group of people) of interest to avoid potential further crimes. This reconstruction process is particularly challenging as the first symptoms of COVID-19 generally appear well after the person is contagious. Reconstruction of past activities is also fundamental in police investigations and time is also of the essence as memory and traces have limited persistence. Both sciences also face the same kind of limitations due to the lack of fully reliable data to support high-risk decision-making processes in complex and quickly evolving contexts.

In forensic science, a lot of suggestions for improvement focus on the need to increase the reliability and relevance of collected data, but most of the proposed solutions also introduce new limitations. For example, accreditation processes are slow, expensive and make the forensic science system less agile to face new types of problem or traces; this is particularly salient in the area of digital forensic science [4]. In the COVID-19 situation, in vitro tests received emergency use authorisation as they were immediately needed, thus temporarily circumventing usual lengthy procedures for new tests implementation. In a crisis like this, an enormous amount of data is collected, most of it probably lacking comprehensiveness and showing significant error rates. It is essential to identify and discard unreliable data and background noise while keeping all information that may be useful to support the decision-making process. Organisations need to be flexible and agile to quickly collect and exchange data of many different shapes and forms (e.g. medical, sociological, economics, etc.) between multiple partners in a collaborative and multidisciplinary approach of the problems. If everybody works in silos (with limited context and bias), ensuring that no data is communicated except if it is 100 % reliable, then solutions might be overlooked or proposed after the crisis has been resolved, at a high societal cost. This situation highlights an apparent paradox: aiming for too much scientific comprehensiveness in the data will limit the timely impact of science on the resolution of problems. At this stage of the pandemic, it seems authorities and the general public understand and accept this pragmatic use of science like they sometimes do when confronted with terrorism threats. Thus, it is a delicate balance between effectiveness and risk of errors (false positive vs negative results) [5] tainted with ethical considerations. This balance may well be struck differently between new threats arising rapidly (e.g. cybercrime) or severe cases (e.g. terrorism, serial killer) in comparison to less serious situations (e.g. break-and-enter cases).

The importance of the context is also essential in both disciplines and explains the multiplicity of models and solutions taken by the different governments facing a complex real-life crisis. The COVID-19 situation has been evolving quickly and very differently between countries. Taking the examples of Italy and Australia, in both countries, the first cases were reported at the end of January 2020. Still, the epidemic spread much more quickly in Italy than in Australia before any government decisions were communicated. It is difficult to know whether these discrepancies are due to different locations, population densities, cultures and behaviours or even weather conditions. The truth probably has multiple inter-related explanations. At this stage, nobody can say with certainty which solutions will prove the best to address the crisis, and these certainly are different for each country and context.

Even after the resolution of the crisis, we may never know which solution was the best, as this is part of the 'prevention paradox' also shared by both disciplines and related in the media by the German coronavirus expert Christian Drosten [6]. Indeed, if the epidemic is significantly slowed down by the measures taken by a government, people will affirm that the actions taken were too harsh and had too much negative impact on the economy. If the epidemic spreads too quickly, leading to higher death rates, then the people will state that the economy was favoured at the expense of human lives. Similar questioning can also be found when considering the roles of forensic science, police services and justice systems to reduce or prevent criminal activity. It is, for example, more difficult to evaluate their impact in the prevention of terror attacks, than to observe their failure to have done so. Adequate measures are a delicate balance between different objectives and must continuously evolve with the situation.

2. Main stages of the COVID-19 crisis as analogy

Looking further into how the COVID-19 crisis has been unfolding, we can identify the following three stages:

2.1. Stage 1: case-by-case treatment and system overload

The first medical priority was the treatment of individual patients within a safe environment (case-by-case approach). An exponential number of COVID-19 patients rapidly created an overload of the health system in many countries. In a much shorter time, hospitals faced the same kind of overload issue as that observed by forensic science laboratories 20 years ago. However, the reaction had to be almost immediate, and no amount of resources and technologies would have been sufficient to face the number of patients needing treatment without at the same time reducing the epidemic spread and establishing priorities based on the chance of survival (such as age and comorbidities, which raised ethical questions). As much information as possible was gathered, such as symptoms, positive tests, patient histories, time delays, treatment, recovery time, etc. to support the decision-making process [7]. The main aim during this stage is to reach patient recovery or case resolution using the best possible evidence. Stage 1 solutions mostly rely on science and may need specialist insights. When a problem has a relatively low occurrence and remains contained, addressing this stage may be sufficient. However, while case-by-case treatment of health and crime issues is considered essential, other measures are also needed to meet society's aims of harm prevention and reduction (e.g. illness and crimes).

2.2. Stage 2: multi-case epidemiological study

Once the seriousness of the COVID-19 pandemic was understood, it was urgent to think about the risk of the propagation and find solutions to limit contamination between people to release pressure on the health system. The focus shifted towards a broader problem resolution requiring a multi-patient approach. Addressing this stage required the proactive detection of infection clusters, attempting to understand the parameters influencing the virus transmission, and prioritising several actions and treatments aiming at 'flattening the curve' and reducing the spread. This situation is analogous to the detection of trace patterns in a multi-

[2] For the sake of simplification, we did not consider accidents that are also studied by both disciplines (sometimes even in collaboration).

[3] Interestingly, this process is often referred to 'contact tracing', re-enforcing the analogy with forensic science.

case approach to better understand crime systems and prioritise security actions to prevent and disrupt criminal activity and behaviour harming society ultimately. Stage 2 solutions require inter-disciplinary collaborations in a problem-orientated approach and often go beyond purely scientific considerations.

2.3. Stage 3: societal impact and planning the future

During the first few weeks of the pandemic, most countries took extraordinary decisions primarily considering the acute health crisis that was unfolding. It was not uncommon to see policies and regulations, although scientifically based and logical, to be implemented by governments outside a regular legislative framework; the extraordinary seriousness of the situation was justifying the means. Similar, but not as extreme, measures have previously been taken by governments following terrorist acts. Once the situation stabilised and started to improve, the full assessment of the impact of both the pandemic per se and authorities' measures (that might generate other problems only visible in a few years) was warranted. This assessment is required to provide a 'big picture' perspective and define a long-term post-COVID-19 outbreak strategy for society. This stage is similar to assessing the impact of organised crime, for example, and the effectiveness of police operations, security measures or forensic science procedures on our security and justice. This stage requires a broader inter-disciplinary approach that should not only focus on public health, in the case of COVID-19, or security outcomes, in the forensic science situation. It must also strike a balance between several scientific, medical, social, legal, economics, ethical and philosophical considerations in varied contexts. Further, Stage 3 solutions also require a community conversation and are inherently political.

3. From COVID-19 to forensic science – the main lessons

The COVID-19 crisis is still unfolding. Notwithstanding the terrible human cost in many countries, it is apparent that the outcome could have been much worse without a widely shared medical and scientific knowledge and expertise informing authorities who mostly took decisions at an extreme pace and with a minimal and only essential regulatory framework. This situation has to be contrasted with solutions commonly proposed and implemented in forensic science that heavily focus on increased quality assurance involving slow, expensive and fragmented processes, control of context and data, etc. not systematically adaptable to new types of problems [8,9].

While the main aim of forensic science laboratories is to help the justice system in a case-by-case approach, they also have the potential to achieve a much broader impact on our societies and justice systems. Indeed, traces can be beneficial to understand crime phenomena and evolution better. Such endeavour can significantly support prevention actions to reduce deviant behaviour harmful to our societies. Further, forensic science is also increasingly seen as having a role to play in the interdisciplinary evaluation of safety and security issues in our communities, including in an ethical viewpoint considering civil liberties and the wellbeing of our society as a whole [10].

While most experts could predict the recurrence of epidemics, nobody could have anticipated how the new virus would spread and affect the human body and our society at large. Thus, while medicine, forensic science and science at large are attempting to predict crisis scenarios, it is vital to be prepared for the unpredictable. In other words, scientists must be able to adapt to case scenarios that were not predicted and are not well understood. Indeed, this crisis shows that there will always be unpredictable events; and addressing a weakness for today does not mean that the system is full proof when the next challenge comes, often with different characteristics that are not considered by the revised 'standard operating procedures'. Thus, it is more productive to design flexible structures and organisations, than to concentrate too much on avoiding one type of risk. Our best assurance to address current and future challenges, particularly in an increasingly digital environment, remains a sound scientific approach, including critical thinking and inter-disciplinary collaborations (along with well-rehearsed procedures). In other words, general education and science education, including forensic science education, has never been as needed as today!

Declaration of Competing Interest

The authors report no declarations of interest.

CRediT authorship contribution statement

Claude Roux: Conceptualization, Resources, Writing - original draft, Writing - review & editing. **Céline Weyermann:** Conceptualization, Resources, Writing - original draft, Writing - review & editing.

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