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Streamlining the forensic autopsy

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Professor Ryan Blumenthal is the recipient of the 2025 NSTF-South32 Communication Award for advancing science, fostering international collaboration and bridging the gap between science and the public through his books, documentary series, conferences and YouTube channel that have raised public awareness and understanding of forensics.

Significance:
The forensic autopsy, in many respects, remains rooted in medieval practice. In today's world of escalating caseloads, human resource shortages and increasing demands on forensic pathology services, this traditional model has become unsustainable. Forensic pathologists now face mounting fatigue and burnout, while institutions struggle with staff shortages and growing backlogs. In resource-constrained and resource-depleted environments, the challenge is not only to keep up with the workload but to preserve the integrity and quality of the forensic system itself. All this must be done while upholding standards and ensuring that the forensic autopsy is adequate.

Background and rationale

This article explores innovative approaches to streamlining the medico-legal investigation of death by rethinking processes so that our limited resources are applied where they are needed most.

By adopting smarter, more efficient strategies, forensic pathologists can conserve resources, improve throughput, and focus on matters of true medico-legal importance. As the global population expands, and demands on forensic pathology services intensify, the profession must urgently reconsider how autopsies are conducted, shifting towards models that are both sustainable and labour-efficient.

Streamlining the forensic autopsy would transform forensic pathology from a labour-intensive, artisanal practice into a smooth-running, evidence-driven system capable of handling modern-day caseloads. It would reduce burnout and fatigue among practitioners, improve efficiency, and allow scarce human resources to be deployed where they are most needed. Such innovation would help maintain standards and credibility, even in resource-limited settings. Ultimately, it would secure the long-term sustainability and resilience of forensic pathology in the face of rising global demands.

Many forensic pathologists in South Africa work under constrained resources while playing a key role in the justice system. The heavy workload of daily forensic casework leaves little time for advocacy, policy input or planning to improve forensic pathology services.¹

Here, the author explores how long-standing autopsy practices might be improved to better meet the needs of modern forensic pathology. By questioning established routines, this perspective encourages the field to adapt and evolve in step with contemporary demands. Streamlining the forensic autopsy is ultimately about strengthening the quality of the medico-legal death investigation system while supporting the sustainability of the practitioners who carry it out.

Current landscape and challenges

Forensic pathology might better be called public safety pathology. The duty of the forensic pathologist is to safeguard the health and safety of their community. Most civilised societies have some sort of death investigating system. In general, about 1% of the population dies every year, and about 20% of those deaths are of such a nature as to require forensic investigation.²

In 2018, the number of forensic pathologists in South Africa was estimated to be 50. This number was deemed woefully inadequate for a country such as South Africa with a population of approximately 57.78 million at the time.³ In 2022, the number of forensic pathologists was estimated to be 60, and in 2024, the number of forensic pathologists was estimated to be 80–90 for a population of 64 007 187.³

The population of South Africa at the time of writing is 64 902 605.³ At present, the Health Professions Council of South Africa lists approximately 80–90 registered specialist forensic pathologists. Considering the definition of unnatural death, South Africa's baseline unnatural death rate, compared with other medico-legal systems worldwide, as well as insights from selected forensic pathologists, South Africa requires approximately five or six forensic pathologists per million people.⁴ South Africa therefore needs 380 forensic pathologists to deliver a quality forensic pathology service.

As forensic science advances, the need for forensic pathology services will also grow. The number of new specialists being trained is far too low to replace those expected to retire over the next 10–15 years.¹ We will also have to look at net additions to the workforce, for example forensic pathology assistants. (Each specialist forensic pathologist requires two or three assistants per autopsy). South Africa therefore requires approximately 760–1140 Forensic Pathology Officers (mortuary technical assistants) for our medico-legal laboratories. We must either expand recruitment and training, improve staff retention or fundamentally reconsider the autopsy process itself. The purpose of this perspective is to advocate for modernisation of the forensic autopsy and the medico-legal investigation of death. Extraordinary progress in recent years has enabled the judicial system to become faster and

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more efficient. Decisions are now more scientifically grounded. Sadly, the same type of thinking has not been applied to the forensic pathology space.

The time has come for a critical rethink.⁵

Contextualising the issue

Forensic pathology, driven by the need for justice, has evolved with changing scientific, technological, social and legal contexts. As a science, it keeps advancing, with people's honour and freedom at stake. While variations exist across countries, the core philosophy of forensic pathology remains consistent: applying medical knowledge and methods to address legal questions and challenges for individuals and society, thereby supporting the administration of law and the pursuit of justice.⁶

Internationally (e.g. USA, Australia, Canada), medico-legal autopsies are performed by a forensic pathologist (known in the USA as a 'medical examiner') assisted by trained technicians, with the forensic pathologist directing the procedure and bearing ultimate responsibility for the findings. In all jurisdictions, the forensic pathologist is accountable for the accuracy of the post-mortem examination and the final report, ensuring comprehensive assessment of all organs and intervening tissues.

Although the prevailing international standard places ultimate responsibility on the forensic pathologist, exceptions do exist: Toronto occasionally utilises "physician assistants" in autopsy practice, and some US medical examiner offices employ a supervised assistant model (often "pathologist assistants") for straightforward cases such as drug overdoses, while the forensic pathologist remains ultimately accountable for the final report and conclusions.

In South Africa, medico-legal postmortem examinations are carried out by an authorised person, appointed by the Province, on the body of a person who has allegedly died from unnatural causes, as soon as is reasonably possible. The National Code of Guidelines for Forensic Pathology Practice (2018; Government Gazette No. 41524), established under the *National Health Act 61 of 2003*, authorises Forensic Pathology Officers (mortuary technical assistants) to conduct eviscerations and organ removals under the oversight of a qualified medical practitioner, in accordance with their designated scope of practice and job responsibilities.⁷ Autopsies are currently conducted by a range of medical practitioners. Some hold a Diploma in Forensic Medicine, while others have completed a Master's in Forensic Pathology. In certain rural areas, however, autopsy services are provided by general practitioners who may not possess advanced qualifications in forensic medicine or forensic pathology.

Defining the problem space

Forensic Pathology Services in South Africa suffers from excessive caseloads, a severe shortage of trained specialists, backlogs and inadequate resources. The purpose of this perspective piece is to ask the difficult questions:

- How can the forensic autopsy process be optimised for efficiency while still meeting the minimum requirements for adequacy?
- How can medico-legal death investigation systems maintain an 'adequate' standard despite chronic underfunding and understaffing?

Clearly, a balanced, data-driven approach integrating resource realities with technological and ethical considerations is urgently needed to strengthen our system.

Historical context

The autopsy itself has not changed significantly over the last century. In 1915, Wadsworth criticised Virchow's second autopsy protocol from 1876, saying it showed how pointless it can be to follow a strict routine. He noted that after hours of examination and a long report, the key detail – a gunshot wound – was barely described, with no proper information on its size, direction or relation to the weapon. Wadsworth argued that a thoughtful, focused examination could have revealed everything important in minutes and in just a single paragraph.^{8,9}

Forensic pathology continues to be the primary domain where autopsies are performed.² Significant financial implications may hinge on whether a death was caused by a workplace injury or not, or whether a heart attack occurred prior to, during or following a motor vehicle accident. Forensic pathology is the study of diseases and injuries of the community. The costs of not modernising the forensic autopsy will therefore be greater than the costs to modernise it.

Although autopsies have been done for thousands of years, there is still no clear agreement on what a 'complete' autopsy should include. Forensic pathologists differ in their approach, often balancing legal duties, ethical duties, workload and practical limits on what can realistically be examined.

Using an evidence-based framework focused on legal requirements, essential findings, and maintaining professional skill can help ensure that the forensic autopsy is as complete as possible.¹⁰

There are two types of autopsies performed by forensic pathologists: autopsies of discovery and autopsies of confirmation.¹⁰ Autopsies of confirmation focus solely on recording findings. For instance, when a death occurs under anaesthesia, the goal is simply to document what happened and what was found. In contrast, an autopsy of discovery is one performed for a sudden unexplained death.

The idea of a 'minimal data set' means that forensic pathologists have duties that go beyond determining the anatomical cause of death, because certain findings can still be valuable to society and the justice system. Matshes et al. described a case in which a forensic pathologist identified a ruptured aortic dissection in a 23-year-old woman and might have felt their legal duty was fulfilled, yet the family was not truly served unless the underlying connective tissue disorder (for example, cystic medial degeneration) causing the dissection was also recognised.¹⁰

Effective legal medicine is essential for achieving justice. The autopsy remains a vital tool in advancing both medical and legal education. Autopsies may reveal the impact of unhealthy habits or undiagnosed conditions, emphasising the need for regular check-ups, lifestyle changes and disease prevention. Autopsies highlight societal well-being, show how genetics, environment, lifestyle and chance affect health, stressing the need for well-rounded health care. They can also reveal mistakes or missed diagnoses, highlighting the importance of learning from errors to improve diagnosis and patient care.

The forensic autopsy needs to stay effective as technology and society change. The forensic autopsy serves the public interest, and extends beyond the requirements of the criminal justice system.¹¹

The data show that autopsies may spark medical research and innovation, thereby advancing treatments and technologies and the understanding of diseases. They also reveal emerging threats, such as new synthetic chemicals, making research in autopsy essential for addressing complex societal challenges.¹² Insurance claims also rest heavily on the findings of forensic pathology autopsies.

Performing an autopsy can be a labour-intensive exercise. Especially when it comes to evisceration, dissection and organ prosection by the forensic pathologists themselves. This is one of the key reasons why the attrition rate is so high. Many forensic pathologists experience burnout and exhaustion, especially in areas with high caseloads. Full-time forensic pathologists tend to work in large cities, primarily because a reasonably large population base is required to support a full-time forensic pathologist.²

Smart solutions

Thirteen smart solutions are hereby suggested to help streamline the forensic autopsy, and ultimately the medico-legal investigation of death:

1. **The Eviscerator-Prosector Method** – In this approach, the forensic pathologist provides overall supervision while delegating the labour-intensive steps of evisceration, dissection and organ prosection to trained Forensic Pathology Officers (mortuary technical assistants). Separate teams are assigned to each stage. If a dedicated scribe is unavailable, Automatic Speech Recognition,



Speech-to-Text or End-to-End Neural Speech Recognition systems may be used. This division of labour streamlines the postmortem examination process, optimises workflow and increases the forensic pathologist's availability for teaching, learning, research and diagnostic interpretation. This solution may work best for high-workload environments. Extensive research confirms that teamwork – embodying the 'many hands make light work principle' – consistently leads to better performance, efficiency and satisfaction in organisations and teams.¹³⁻¹⁵

In practical terms, the eviscerator–prosector method involves a structured division of labour during the autopsy. One team member performs the evisceration, another systematically dissects the organs (the prosector), while the forensic pathologist documents findings in real time and supervises the entire workflow, providing interpretive oversight and ultimately assuming full responsibility for the conclusions and formal sign-off. The benefit of such a system is that it distributes the operational workload across the team, thereby freeing the forensic pathologist to focus on higher-order functions such as teaching, learning, research and expert interpretation. Another team member may take photographs, specimens and samples for academic and evidentiary purposes.

2. **Forensic Autopsy Triage Protocols** – In this approach, evidence-based guidelines may help distinguish natural deaths from unnatural deaths (for example, homicides, deaths-in-custody, suspicious deaths vs natural, well-documented cases). Triage may also help reduce unnecessary autopsies while preserving medico-legal integrity. Natural deaths may come under the jurisdiction of a forensic pathology service when the circumstances surrounding the death are uncertain, unexplained or potentially unnatural at the time of reporting. In such cases, a forensic postmortem examination is required to exclude unnatural causes, to confirm the medical cause of death, and to address any legal or public health considerations.

The diagnosis of unnatural death may be challenging for medical practitioners, and the use of a structured algorithm supported by multidisciplinary review – potentially through a dedicated death review board composed of a general practitioner, law enforcement, judicial representation, social services, and a forensic pathologist – could assist in improving consistency and oversight.

3. **Digital Case Pre-Screening** – Electronic intake systems can be implemented to capture the medical history, scene information and investigative reports prior to autopsy. Pre-screening may help trim the workflow and prevent redundant procedures. Consideration could also be given to deploying personnel trained in medico-legal death investigation or those holding a BSc or MSc in medical criminalistics to pre-screen cases prior to autopsy, in much the same way that nursing staff triage and screen patients before admission.
4. **Minimally Invasive Forensic Autopsies**¹⁶ – Targeted dissections may be utilised. For example, needle biopsies and endoscopic approaches may be used as alternatives to full autopsy where appropriate. Minimally invasive autopsies may conserve time, reduce staff fatigue, reduce occupational health and safety risks, and maintain diagnostic yield.
5. **Virtopsy / Imaging-Based Forensic Autopsy / Tele-Forensic Pathology** – Incorporating postmortem CT, MRI, ultrasound and 3D scanning may complement or even replace traditional autopsies. Virtopsy has been proved to be effective in cases of blunt force trauma, fractures, foreign body detection and high-volume triage.^{17,18} Virtopsy represents a global shift toward imaging-based postmortem examination, offering technological benefits and improved cultural and religious acceptability by avoiding invasive dissection. Interpretation of these studies sits at the intersection of radiology and forensic pathology, with radiologists providing image analysis and forensic pathologists integrating findings into medico-legal conclusions. Optimal practice relies on collaborative reporting or cross-training

to ensure accurate and context-appropriate cause-of-death determination. Certain well-resourced medico-legal facilities around the world use postmortem CT prior to autopsy. In settings in which no formally trained forensic pathologist is available, tele-forensic pathology may be considered as an adjunct to support medico-legal death investigation.

6. **Standardisation and Lean Process Engineering** – Lean and Six Sigma (LSS) are widely used methods to improve efficiency, cut waste and enhance quality across industries. LSS merges Lean's focus on speeding up processes and reducing waste with Six Sigma's aim to minimise defects and stabilise processes, creating an effective approach to operational improvement.¹⁹ LSS is therefore a well-structured, data-driven methodology that integrates waste reduction with process variation control to improve efficiency, quality and reliability within complex systems. Such methodologies may be applied to forensic autopsy workflows, which may help enhance standardisation, reduce bottlenecks and ensure quality control. LSS may enable systematic improvements through approaches such as DMAIC (Define, Measure, Analyse, Improve, Control). This integrated framework facilitates the standardisation and simplification of processes, reduction of errors, optimisation of workflow and enhancement of employee development, ultimately improving operational performance, reliability and stakeholder satisfaction. LSS has been widely applied in healthcare, laboratory and industrial settings to optimise efficiency, modernise, reduce costs and increase service quality.²⁰
7. **Centralised High-Throughput Autopsy Centres** – Regional megamortuaries staffed by specialised teams – such as trauma, paediatric and toxicology units – would enable the efficient management of large and complex caseloads. This model mirrors the principles of centralised laboratory testing, where consolidation improves capacity, standardisation and overall service quality. Implementing large-scale batching of toxicology samples, for example, could substantially reduce analytical bottlenecks and help prevent backlogs.
8. **Task-Sharing and Workforce Redesign** – Delegate tasks such as external examinations, toxicology sampling, photography, and evisceration to trained Forensic Pathology Officers (mortuary technical assistants). Delegation frees forensic pathologists to focus on interpretation, teaching, learning and decision-making.¹³⁻¹⁵ Task-sharing and workforce redesign should also include the delegation of cleaning, administrative, storage and archiving functions, guided by standardised protocols to maintain quality and medico-legal standards. Teams tend to succeed when they demonstrate effective coordination, clear communication, adaptability, and operate within supportive organisational environments.²¹
9. **Artificial Intelligence (AI), Digital Solutions, Robotics and Machine Learning** – Employ AI for image recognition, toxicology interpretation and predictive analytics in cause-of-death classification. AI may enable rapid triage and help reduce manual workload. The Fourth Industrial Revolution has accelerated the integration of robotics and AI into workplaces, creating opportunities to merge technology with real-world practice. Drones and mobile quadruped agile robots may be used for high-risk and hazardous death scene investigation (such as fires, chemical or radioactive death scenes), thereby protecting staff from occupational health and safety risks.²² Digital solutions developed within the legal sector – such as applications ('apps') or secure messaging platforms – could provide real-time updates on the attendance of all court participants, thereby reducing the substantial time and travel burdens currently experienced by forensic pathologists who often arrive in court only to find that key parties are absent, or that the matter has been postponed.
10. **Selective Ancillary Testing Strategy** – In forensic pathology, it is not possible to perform a truly 'complete' autopsy that includes every imaginable test.¹⁰ This will bankrupt the entire system. Replace blanket toxicology, histology, microbiology and molecular tests with targeted, risk-stratified testing. Selective testing, or

outsourcing of testing, may help reduce costs and turnaround time while maintaining diagnostic accuracy.

11. **Continuous Quality Assurance and Accreditation Alignment** – The implementation of feedback loops, benchmarking and international best-practice audits may help ensure sustainability, credibility and compliance with global forensic standards.
12. **Private–Public Partnerships** – Family-requested autopsies and private forensic autopsies may be performed on a private basis by appropriately qualified specialist forensic pathologists registered with healthcare funders and in possession of a valid PCNS (Practice Code Numbering System) specialist number. Outsourcing special investigations – such as CT, MRI, molecular studies, histology and toxicology – may also help decrease pressure on the medico-legal death investigation system.
13. **A SWOT Analysis of the Medico-legal Death Investigation System** – Streamlining the medico-legal death investigation system to improve efficiency and timeliness represents a complex, multifactorial challenge that cannot be addressed by focusing on the forensic autopsy alone. Forensic Pathology Services operate within diverse organisational models – some integrated with academic institutions that prioritise teaching, research and training obligations, while others function in rural or resource-constrained settings with limited personnel and infrastructure – creating heterogeneous operational realities across jurisdictions. Effective reform must therefore encompass the entire medico-legal death investigation system, including forensic pathologists, detectives, prosecutors and laboratories, while engaging all relevant stakeholders to ensure buy-in and sustainability. Central to any successful transformation is the establishment of a truly independent Forensic Pathology Service supported by a ring-fenced budget and protected from competing institutional demands. A comprehensive review and modernisation of the legislative and regulatory framework is also recommended. A structured SWOT analysis should be conducted at national and provincial levels to identify specific strengths, weaknesses, opportunities and threats, with targeted, evidence-based interventions subsequently developed and implemented for each identified pillar, thereby providing a systematic pathway toward sustainable improvement in forensic autopsy turnaround times and overall service delivery.

Understanding the scale and significance of the issue

While many of the proposed smart solutions have the potential to improve efficiency and resilience, their implementation inevitably requires financial investment; in the absence of additional government funding, Forensic Pathology Services will need to rely on strategic prioritisation and evidence-based optimisation of existing resources to sustain service delivery.

There is a real concern that any unexpected surge – whether a mass disaster or a public health crisis – could overwhelm a system already operating at the limits of its capacity.

The proposed smart solutions must be balanced against practical constraints. With limited resources and staffing, forensic pathologists continue to do the very best we can with what we have, prioritising certain cases and maintaining a focus on high-quality, evidence-based reporting.

In a resource-limited setting, it is essential to allocate both material assets and human capital to ensure the sustainability and effectiveness of Forensic Pathology Services.

Implications for South Africa

Data show that the most recent forensic medicine textbook in South Africa was published in 1988.²³ The population in South Africa was approximately 38.48 million people at the time of publication.³ As mentioned, the population of South Africa at the time of writing is approximately 64.9

million.³ There has thus been an increase of 26.42 million people in South Africa in the last 37 years. The medico-legal infrastructure in South Africa has not changed significantly in the past 37 years.²⁴

In the USA, a data-driven predictive model for the supply of pathologists (the Robboy model) was published.²⁵ It combined multiple data sources to forecast how retirements, training output and demographic change would affect workforce numbers and patient access to pathology services. Overall, the predictive analysis issued a clear warning of impending shortages and urged educators, policymakers and professional bodies to expand training capacity and adapt to evolving market forces.

South Africa currently faces an acute and entrenched forensic pathologist crisis. Salary disparities, limited postgraduate training positions and an aging workforce are driving emigration and urban–rural maldistribution.

Without immediate annual expansion of residency posts, improved remuneration and accelerated implementation of technologies and task-sharing, South Africa faces a severe collapse of forensic pathology services.

South Africa, with our high unnatural death burden, demands urgent, scaled interventions to prevent catastrophic impacts on diagnostics and equitable care.

The Robboy model offers a blueprint and serves as a stark warning.²⁵ Not having enough pathologists will negatively impact services, especially as diagnostic demands grow. The purpose of this perspective is to help model a framework to forecast South Africa's needs, emphasising greater investment in the medico-legal investigation of death, rethinking how we perform autopsies, and targeting new forensic pathologists through expanded training and retention strategies.^{4,25}

Data indicate that South Africa's forensic pathology service is under strain, resulting in case backlogs, with only 80–90 specialist forensic pathologists serving a population exceeding 64 million in the context of approximately 70 000 unnatural deaths annually; in certain rural areas, autopsy services are provided by general practitioners who may not possess advanced qualifications in forensic medicine or forensic pathology. This burden is compounded by high individual caseloads (often > 250 autopsies per forensic pathologist per year), marked provincial disparities and persistent backlogs in toxicology and DNA analyses. Ongoing emigration and occupational burnout are further undermining the capacity and sustainability of medico-legal services.

Conclusion

Despite ongoing constraints in funding and personnel, forensic pathologists remain committed to delivering high-quality work with meaningful societal impact, even as we continue to advocate for the sustainable infrastructure that our communities so urgently require.

Using tools such as advanced imaging, molecular tests, artificial intelligence, robotics, tele-forensics and data analysis – together with better staffing and clear and intelligent policies – the forensic autopsy, together with the medico-legal investigation of death, can be modernised, scaled and strengthened.

If decisive action is not taken to invest in streamlining the forensic autopsy process, expanding forensic pathology training, improving public-sector remuneration, and implementing newer technologies and task-sharing, South Africa risks the near-total collapse of timely and reliable medico-legal death investigation.

Such failure would critically impair the ability to render a quality forensic pathology service, deliver justice, ensure public safety, protect vulnerable communities and provide closure to bereaved families.

Declarations

The author has no competing interests to declare. 'Consensus AI' was used for research references.

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