

## EDITORIAL

# Creating Macao Medical Simulation Centre to improve safety, quality and education in health care (Center of Excellence for Medical Professional Development)

Billy Chan,<sup>a</sup> Manson Fok,<sup>a</sup> Ross Horley,<sup>b</sup> Nivritti Patil<sup>a</sup> and Eric Luis<sup>a,\*</sup>

<sup>a</sup>Faculty of Medicine, Macau University of Science and Technology, Macau SAR; <sup>b</sup>Faculty of Medicine, University of Notre Dame, Fremantle, Australia

\*Corresponding author at: Faculty of Medicine, Macau University of Science and Technology, Macau SAR.

Email: [laguntureric@must.edu.mo](mailto:laguntureric@must.edu.mo)

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## Abstract

Between 2011 and 2020, in the Macao Special Administrative Region, China, critical health care reforms took place with simulation training in medical education. The introduction of simulation training for postgraduates at the Faculty of Health Sciences at the Macau University of Science and Technology (MUST) was a key driver of this health care services reform, supported with two public health care lecture forums: the Sino Luso International Medical Forum launched in 2011 and the Sino Asia Pacific Medical Forum, established in 2015. Advocacy and education from these forums also helped pave the way for approval from the Macao SAR Government Gazette of the first Bachelor of Medicine, Bachelor of Surgery (MBBS) programme on 14 January 2019. The programme was launched on 2 September 2019 at the newly opened Faculty of Medicine (formerly Faculty of Health Sciences) at the MUST. The strategy was based on a three-pronged approach, starting with the implementation of simulation-based postgraduate training programmes, creating internationally supported medical lecture forums, and ending with the establishment of the medical school. The strategy has led to a solid foundation to successfully adopt leading-edge technology for medical and clinical training and education, meeting the needs of future health care and health care providers.

**Keywords:** Macao Special Administrative Region; China; simulation training in medical education; Macau Medical School; health care reform

## Introduction

Before 20 December, 1999, when Macau started the process of handover from a territory of Portugal to a Chinese region, local doctors obtained their medical degrees outside Macau, mainly in Portugal, Mainland China, or Hong Kong. Postgraduate training and continuing medical education were conducted in Macau on a small scale and consisted of lectures, demonstrations, and supervised hands-on procedures on patients.

Many Macau-based practitioners obtained further skills training in Hong Kong, Mainland China, or abroad. Therefore, the development of skills away from a patient was not usual in Macau. There was an increasing trend around the world to incorporate simulation technology into medical skills training programmes, eliminating reliance on the traditional forms of training, i.e. on patients, animals, and cadavers. Furthermore, there was firm

evidence showing that training on real patients placed those patients at unnecessary risk, and that simulation was a faster and safer way to develop clinical skills.<sup>1,2</sup> Macau also did not have animal or cadaver dissection laboratories; therefore, resources for ongoing training were limited. In parallel, Macau was also experiencing an escalation in visitor numbers with the rollout of more casinos and hotels. This placed an additional burden on the health system and highlighted the need to have a medical workforce highly trained to international standards.

To address the needs and shortfalls in medical training in Macau, the Macau University of Science and Technology (MUST) Faculty of Health Sciences (now Faculty of Medicine) developed a three-pronged strategy. First, in 2011 the faculty established a simulation-based skills programme for postgraduates and developed a clinical skills and simulation training centre called the Center of

Excellence for Medical Professional Development (CEMPD). On 11 November 2011, the centre was endorsed by the Chinese Medical Doctors Association, then with 2.6 million members (now >4 million). The second prong was to give Macau doctors access to international leaders in clinical excellence, and the Faculty of Health Sciences launched two public health care education programmes with simulation training at their core: the Sino Luso International Medical Forum (2011) and the Sino Asia Pacific Medical Forum (2015). The third prong was the establishment of a medical school in Macau in 2019.

## Developing a simulation-based skills programme

The first training programme was focused on disaster management. Courses that have taken place between 2011 and 2020 for postgraduate training include disaster management and life support courses, specific procedural courses and international workshops.

### Disaster management and life support courses

Disaster management and life support courses include advanced cardiovascular life support; basic life support, paediatric advanced life support, and neonatal life support.

### Specific procedural courses

Specific procedural courses include airway management, bronchoscopy, cardiology, endoscopy, laparoscopy, minimally invasive surgery, obstetrics (difficult child birth), orthopaedic (knee and shoulder, spinal, etc.), ultrasound imaging and robotic surgery.

### International workshops

Aligned with the aim to provide a world-class training centre, CEMPD facilitates several internationally accredited workshops, such as:

- Practical Obstetric Multi Professional Training (PROMPT) led by Professor Tim Draycott, Department of Obstetrics and Gynaecology, University of Bristol, United Kingdom
- The Advanced Disaster Medical Response, counselled by its author, Dr Susan Briggs, Director, International Trauma and Disaster Institute, Department of Surgery of Massachusetts General Hospital, and Associate Professor of Surgery at Harvard Medical School
- The Royal College of Surgeons of Edinburgh (RCSED) Non-Technical Skills for Surgeons (NOTSS)

From 2011 to 2020, >10,000 local and regional health care workers were trained in new techniques in medical procedures at the CEMPD. As a testament to the training activities at the centre, the Royal College of Surgeons, Edinburgh, has recognized CEMPD for its advancement in medical and clinical skills training.

Please refer to Appendix 1 for information on current simulation equipment and e-learning software at CEMPD.

## Sino Luso International Medical Forum and Sino Asia Pacific Medical Forum

Although Macau has cultural roots and medical traditions with the Portuguese-speaking world and the Chinese world, the Sino Luso International Medical Forum sought to integrate both to provide a cross-cultural lecture series leading to greater knowledge, understanding and collaboration between health jurisdictions. Further, leading medical experts from non-Portuguese-speaking nations were included. Six forums were held annually; 52 were conducted by January 2020. The Sino Asia Pacific Medical Forums were also launched as a biannual event to work more closely with regional partners in Mainland China and Southeast Asia, primarily China, the Philippines and Cambodia, aligned to the Greater Bay Area of the China Belt and Road Initiative.

The overriding theme for both forums was the development and deployment of simulation-based medical and clinical training. This exposure allowed local health care providers from Macau greater information and knowledge on regional clinical processes, education and training, such as different regions' response efforts to natural disasters such as typhoons and tropical diseases.

## International recognition: notable visitors and international experts at Macao Medical Simulation Centre

A primary goal for the CEMPD was to promote simulation-based training to the medical community but also to promote the centre and its activities to health leaders internationally. Over the course of 9 years, many health ministers, senior government officials, and international health care experts visited the centre and attended the medical forums. Some notable individuals include:

- 2011–2012: Dr Huang Jiefu, Minister of Health of the People's Republic of China; the late Professor Gao Changqing, the "Father" of robotic surgery in China;

Professor Yang Jing, Executive Vice President of the China Medical Doctors Association

- 2013: Professor Zhang Yanling, Health Director of the People's Liberation Army of the PRC; Dr Chen Xiaohong, Vice Minister of the Health Ministry of the PRC; Mr Zhang Junhua, Deputy Director-General of the Health Human Resources Development Center of the Ministry of Health of the PRC; Mr Ian Ritchie, President of the Royal College of Surgeons, Edinburgh, UK
- 2014: Dr Maria Calimag, President of the Philippines Medical Association, Senator Emanuel Jones US State Senator, Georgia, USA
- 2016: H.E. Linda Yim, President of the Doctor Alliance Union Youth Federation of Cambodia; Mr Michael Lavelle-Jones, President of the Royal College of Surgeons, Edinburgh, UK
- 2017: Dr Ron Harden, Professor Emeritus of Medical Education at the University of Dundee, and then Secretary General of the European Medical Education Association (AMEE), and creator of the Objective Structured Clinical Exam (OSCE)
- 2018: Dr He Zhaohua, Deputy Director of International Cooperation National Health Commission (formerly Ministry of Health); Dr Herminigildo V. Valle, Undersecretary of Health of the Philippines; Dr Florentino Cardoso, President of the Brazilian Medical Association; the centre also hosted an Olympic sports delegation of doctors from Angola, Cape Verde, Mozambique, and Portugal
- 2019: Dr Paulyn Jean B. Rosell-Ubial, former Philippines Secretary of Health; Hon. Mr Chanaka Denagama Vitharanage, Member of Parliament of the Democratic Socialist Republic of Sri Lanka; Ms. Nithya Senani Samaranayake, Member of the Colombo Municipal Council

To increase international health care collaboration and further establish CEMPD internationally, Professor Manson Fok of the Faculty of Health Sciences, MUST, signed a Joint Communique with former Portuguese President General Ramalho Eanes and others, including 20 countries.

Professor Manson Fok and executive members of the Sino Luso International Medical Forum further promoted global medical simulation education exchanges with meetings in Porto with officials such as Dr Luis Gomes Sambo,

Minister of Health to Angola and former Director of WHO, and Dr Alberto Vaquina, former Prime Minister of Mozambique.

In its first 2 months, the Faculty of Medicine has welcomed guests from the National Health Commission (formerly Ministry of Health), the Ministry of Education (PRC), Peking University, University of Lisbon, University of Porto, Tel Aviv University, Hong Kong Association of the Pharmaceutical Industry, the Journal of Nature Medicine, Huawei, Tencent, Fintech Alliance, Pollinate and Advanced Oncotherapy from the United Kingdom.

## MUST Medical School

On 6 September 2019, MUST established the new Faculty of Medicine (formerly Faculty of Health Sciences). This was the third prong of the strategy that was initiated in 2011 under Dean Manson Fok's leadership. The first batch of students numbered 49. A new state-of-the-art medical training facility was built on the MUST campus, adding to its increasing international status. The campus is now ranked 250<sup>th</sup>–300<sup>th</sup> in 2020 in the Times Higher Education World University Ranking and among the top 30 of all universities in Greater China.<sup>3</sup>

A 60-bed university hospital, which opened on the MUST campus in 2006, is also a significant resource for the Faculty of Medicine and compliments the State Key Laboratory of Quality Research in Chinese Medicines and a government hospital run emergency ward. Currently, the centre is around 1000 m<sup>2</sup>. There are dual entrances for students to avoid the possibility of colliding in hallways if there are multiple classes taking place.

The training rooms in the centre include a conference room, one large simulation lab for imaging, one large simulation lab for minimally invasive surgical simulations, shown in Fig. 1, one mock up operating theatre, an e-learning room, a virtual reality anatomy room, a mock up emergency room/intensive care unit, a large classroom, a large simulation triage area with mock ambulance set up and storage rooms.

Two specially designed rooms are also equipped with one-way reflective mirror partition, only allowing teachers in the control room to observe, in unilateral direction, the performance of students in the examination room (Fig. 2). Simulation exercises in bronchoscopy, colonoscopy and obstetrics are shown in Fig. 3. Neuroimaging simulation exercises with coiling of aneurysm are shown in Fig. 4, and simulation exercises in prostate surgery and suturing are shown in Fig. 5.



**Figure 1.** Minimally invasive surgery simulation equipment.



**Figure 2.** One-way reflective mirror partition separating control room from examination room.

Courses offered for different professional categories are shown in [Table 1](#). Also see Appendix 2 to for a list of past courses delivered in Macao.

### International collaboration

Building on the momentum since 2011, the Faculty of Medicine now has international collaborations with Massachusetts General Hospital; Harvard Medical School; the American College of Surgeons; Royal College of Surgeons; European Association for Endoscopy Surgery

and other Interventional Techniques; Stanford University; Karolinska Institute; University of Notre Dame Australia; and Edith Cowan University Australia.

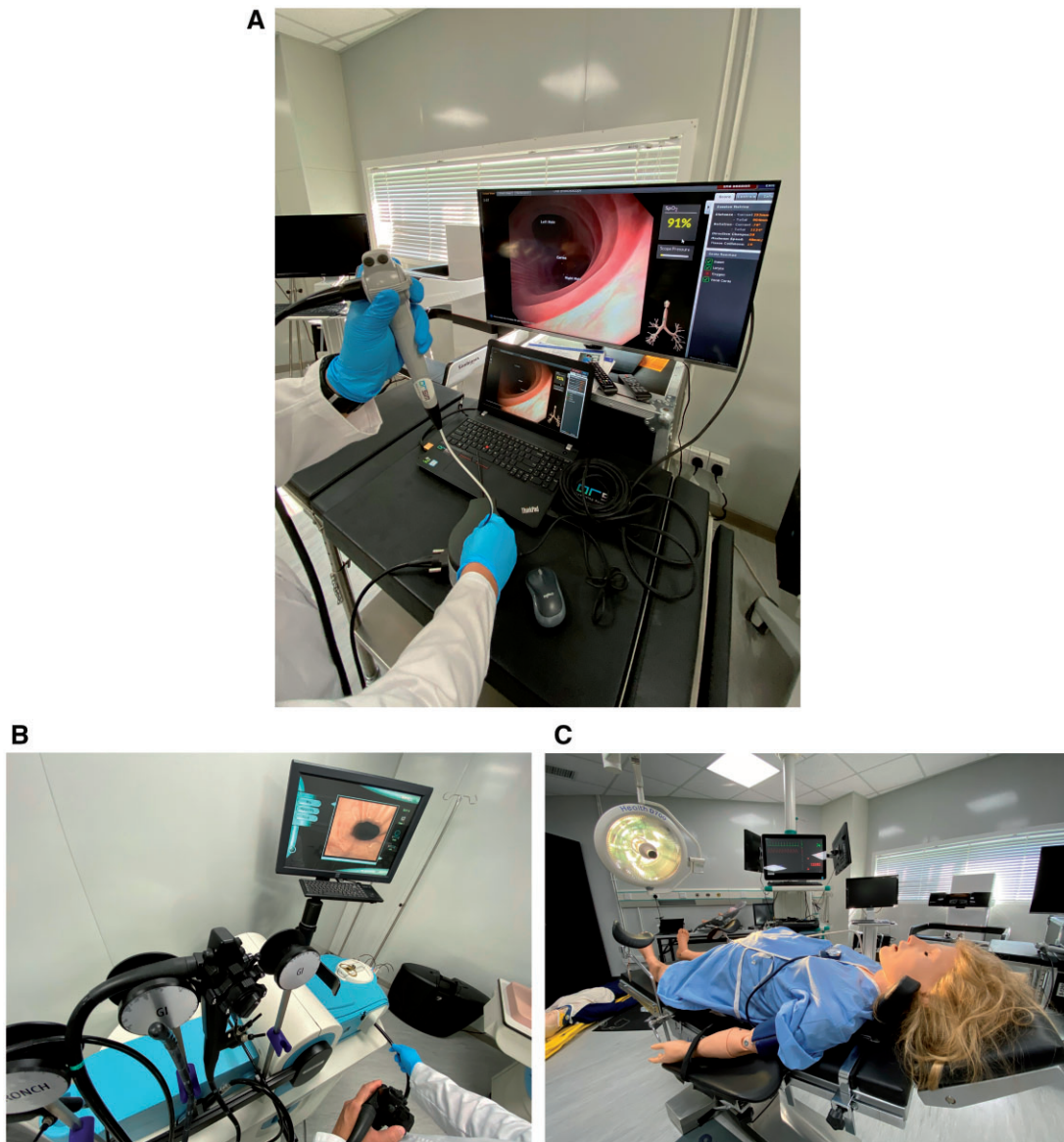
In November 2019, the Faculty of Medicine of MUST became a founding member of the World Portuguese-Speaking Countries Medical School Alliance. This alliance includes 12 universities from the Portuguese-speaking world: University of Lisbon, University of Porto, University of Coimbra; Federal University of Rio de Janeiro, University of São Paulo, University of São Paulo at Ribeirao Preto, Federal University of Minas Gerais, Federal University of Rio Grande do Sul, Federal University of Ceara, Federal University of Bahia, Agostinho Neto University and Eduardo Mondlane University.

### Objectives and deployment of simulation as a result of the COVID pandemic

From September to December 2019, courses developed by the core team of the Faculty of Medicine utilized foundation block training for competency based learning. These included basic suturing (knot tying technique), basic airway management, anatomy classes, communication skills classes, gastrointestinal simulation (basic endoscopy intro), basic life support (CPR), and resuscitation with accident and emergency department.

Objectives in simulation training with three domains were introduced to the MBBS students during this period. The





**Figure 3.** Simulation exercises in bronchoscopy (A), colonoscopy (B) and obstetrics (C).

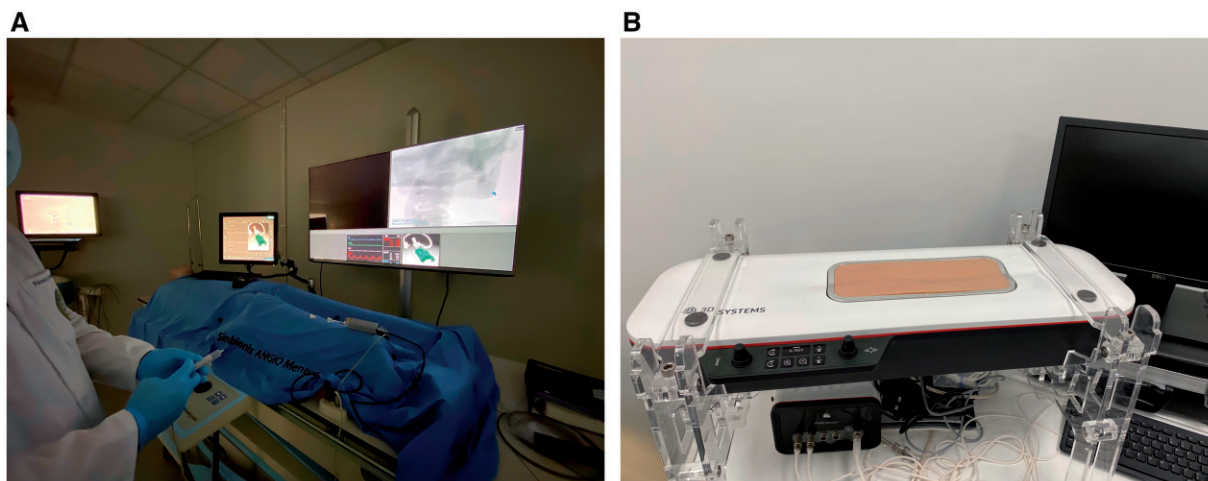
first was cognitive objectives (medical knowledge), asking: “What do you want your medical students to know?” The second was psychomotor objectives (skills-based training), asking: “What do you want your medical students to be able to do?” The third point pertained to affective objectives (attitude and behaviours), asking: “What do you want your medical students to think or care about?” Primary taxonomies include cognitive anatomy, e-learning, pathology 3D (models, specimens, “Anatomage” Digital Autopsy System).

The technical training involved psychomotor skills, perceptual skills, virtual reality, manikins, accident and emergency department, auscultation, suturing skills, and hands-on

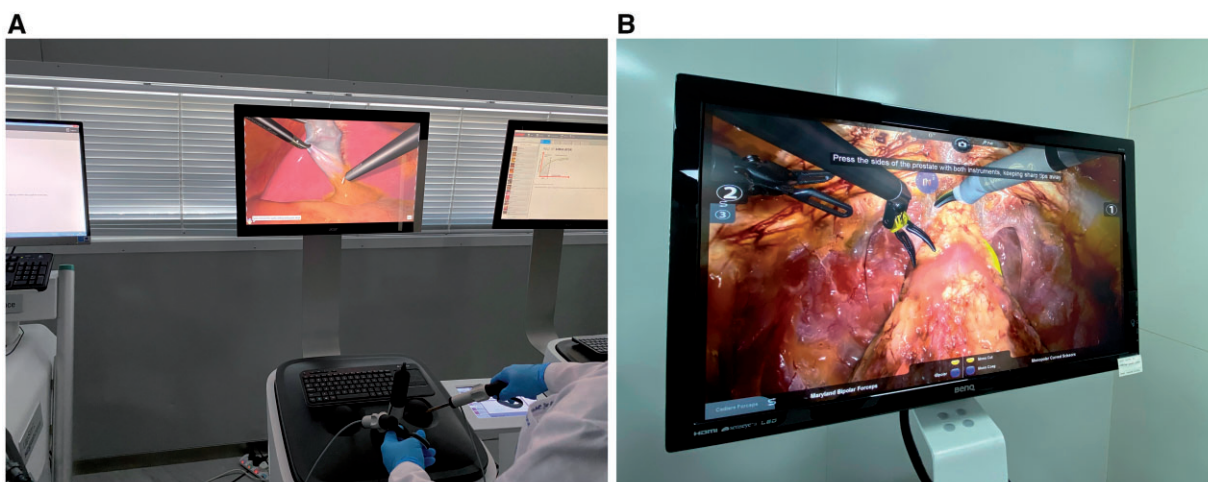
technical skills, etc. Non-technical training involved communications, medical English, team training, and role-playing scenarios.

After the outbreak of SARS-CoV-2, all universities in Macau were ordered to postpone face-to-face classes after the Lunar New Year on 25 January 2020. In accordance with the policies set forth by the MUST, Faculty of Medical classes went online in mid-February. Over 100 courses for anatomy, pathology, physiology have been held with online technologies.

With the new 2020-2021 academic year commencing in September and a new class of nearly 50 incoming students to bring the total student body to about 100 first and second year students, there will be a much higher dependence on



**Figure 4.** (A) Neuroimaging simulation; (B) lumbar puncture simulation.



**Figure 5.** Simulation exercises in gallbladder surgery (A) and prostate surgery (B).

simulation and new and emerging technologies going forward.

## Creating awareness

Simulation training for medical education was a new offering in Macau in 2011, therefore a degree of public and clinician awareness needed to be established. At certification workshop and formal activities, for example, critical messages were explained to attendees and the media that a better-trained health care workforce results in greater quality of patient care with less medical error. There were eight major messages:<sup>4–7</sup>

1. Simulation allows doctors, nurses, health care workers to learn skills without practicing on patients and therefore avoids putting patients at risk
2. Simulation provides significant cost benefits to hospitals and health care organizations
3. Simulation can significantly decrease the time to gain skills competency
4. Deployment of new technologies such as artificial intelligence (AI) as a diagnostic tool should not be seen as a threat to current medical practice
5. Simulation is measurable and therefore simulation-based training programmes can be tailor-made to address trainees' weaknesses
6. Mistakes are made and are totally acceptable in the simulation lab, reducing the chance of mistakes on the ward or in the operating theatre

**Table 1.** Courses offered

Professional categories	Course description
Anaesthetists	PROMPT Certificate Course - Practical Obstetric Multi-Professional Training Certificate Course in Aesthetic Medicine and Dermal Therapy Bronchoscopy Skills Training Spine & Articulation Pain Syndrome Workshop Advanced Laparoscopic Course Tele-Robotic Surgery (Radical Prostatectomy) Workshop Crisis Resource Management (CRM)
Cardiologists	Endovascular Percutaneous Coronary Intervention Course Ultrasound-Guided Vascular Cannulation and Catheter Placement Clinical Ultrasound Course - Transthoracic and Transesophageal TEE Intermediate Echocardiography Ultrasound Certificate Course
Emergency and Critical Care	The Intermediate Emergency Ultrasound (EFAST) Advanced Airway Management Course Crisis Resource Management (CRM)
Medical Students	Basic Suturing Workshop Intravenous Cannulation and Venepuncture Course Abdominal System Examination Module 101 Respiratory System Examination Module 101 Cardiovascular System Examination Module 101 Male and Female Pelvis Examination Module 101 Digital Rectal Examination Module 101 Chest Drainage Management Module 101 Breast Examination Module 101 Thyroid Examination Module 101 Central Venous Catheterization Module 101
Nurses	Health Assessment Course: ICU health assessment of various systems; interpretation of laboratory findings; chest X-ray and compute tomography brain interpretation; echocardiogram; pain and trauma assessment Intravenous Cannulation and Venepuncture Course Crisis Resource Management (CRM)
Orthopaedic	Interventional Pain Management Workshop
Palliative care	Advanced Care-taking and Treatment Techniques for Alzheimer's Disease Course
Radiologists	Clinical Practice Procedures (Basic): Assessment/ Ultrasound Obstetric Ultrasound Certificate Course Musculoskeletal Ultrasound Clinical Skills Certificate Course Urological Ultrasound (ultrasound for the kidney, bladder, scrotum and prostate) Gastrointestinal System Ultrasonography Certificate Course Echocardiography: Scan Plane and Measurement RACEplus (Rapid Assessment by Cardiac Echo plus) Breast and Thyroid Ultrasound Clinical Skills Certificate Course The Intermediate Emergency Ultrasound (EFAST) Ultrasound of the Hepatobiliary-Pancreatic System Course Abdominal Ultrasound Certificate Course Intermediate Echocardiography Ultrasound Certificate Course Ultrasound of the Hepatobiliary-Pancreatic System Course

7. It allows for compliance to international standards of professional competency
8. It removes/reduces the use of animals and cadavers for medical training

Mandating simulation was also advocated in these forums noting that simulation-based training is being integrated as a mandatory training technology in world leading medical schools and health institutions. In addition, clinical case studies of the US Food and Drug Administration and its Center for Devices in Radiologic Health (CDRH) were cited at public lectures. For example, CDRH approved the use of carotid stents in 2005; the agency stipulated that doctors performing this procedure must follow the training guidelines of the stent manufacturers; and that these guidelines call for practice on a simulator to attain proficiency.<sup>8</sup>

## Conclusion

From the beginning, a clear three-pronged strategy was devised, then delivered over the 9 years considered for this report. This approach has provided a sound foundation for the future success and sustainability of the School of Medicine. The focus on the incorporation of new training technologies as an embedded pedagogy for both undergraduate and postgraduate medical training programmes will enhance the students' experience, provide for rapid skills acquisition and greater knowledge management, producing better doctors. Further external factors are having a flow on benefit to MUST. The region is technology driven. In 2020, Macau became the first city in China to have fully functioning 5G technology. Break-neck advances in AI and IoT (Internet of Things) are transpiring in the regional Greater Bay Area of Guangdong province, in which Macau plays a key role.

The future incorporation of AI and IoT at our skills centre will provide an opportunity for a special new research arm for medical informatics as well as rapid diagnostics for identifying novel diseases and other newly emerging pathogens. MUST and the School of Medicine will be at the forefront of technology-driven medical care. The implementation of these technologies and the surrounding advanced infrastructure will enable rapid learning opportunities for skills-based and diagnostic tasks without dehumanizing medical treatment. The net result is better care for patients.

## Conflict of interest

The authors declare no competing interests.

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## Appendix 1

Current Equipment at CEMPD E-learning software includes:

- Pathology 3D
- Anatomage with MD Studio (full size body with four sets of cadavers)
- DRx virtual patient software
- AI software (VisualDx)

Simulation equipment includes:

- Manikins (low fidelity and high fidelity)
- Abdominal exam trainer
- Ultrasound-guided cannulation (central line cannulation, femoral line cannulation)



- Intravenous cannulation arms and simulator
- Pelvic trainers
- Rectal trainers
- Breast examination trainers
- Ultrasound machines
- Ultrasound simulators (abdominal, transvaginal)
- TEE echo simulator
- Arthroscopy simulator (knee and shoulder)
- Laparoscopy simulators (haptic and nonhaptic)
- Upper and lower GI endoscopy simulator including ERCP
- Endovascular simulator (peripheral, cardio, neuro type interventions)
- Robotic surgery simulator (basic to advanced gynaecology, urology, etc)
- Birth manikin (mechanical childbirth)
- Neonatal manikin (newborn)
- Baby manikin (6 months)

Airway and bronchoscopy simulators. Clinical equipment includes:

- beds/tables; monitoring equipment (pulse oxymeter, cardiomonitoring device, blood pressure device)
- respiratory support equipment for adults and newborns (Ambu bags with masks for adults, pocket masks, suction, laryngoscopes)
- endotracheal tubes of all sizes
- defibrillators
- suturing kits (forceps, sutures, scissors, scalpel, blades, pads)
- intravenous catheters for adults
- infusion systems

Additional technical equipment includes an advanced video and audio system, smart TVs in teaching areas, and portable smart TVs on trolleys.

## Appendix 2

### Training courses conducted between 2011 and 2019

Our faculty developed and organized a variety of courses covering a range of specialties and themes between 2011 and 2019. We hosted and supported several local courses in our purpose-built simulation space.

M001. Safer Operative Surgery (SOS) Course for high performing teams in the operating theatre

M002. Non-Technical Skills for Surgeons (NOTSS) Masterclass

M003. PROMPT Certificate Course (Practical Obstetric Multi-Professional Training)

M004. Endoscopy Course

- Endoscope handling
- Basic method in gastroscope insertion and examination of upper GI tract
- Basic method in colonoscope intubation and examination of lower GI tract
- Recognition of upper and lower GI common pathology
- Simulation and Endo-trainer exercises

M005. Certificate Course in Laparoscopic Basic Skills  
M006. Laparoscopic Suturing Workshop

M007. Health Assessment Course

- ICU health assessment of various systems
- Interpretation of laboratory findings
- Chest x-ray and computed tomography brain interpretation
- Echocardiogram and pain and trauma assessment

M008. Intravenous Cannulation and Venepuncture Course

M009. Endovascular PCI (Percutaneous Coronary Intervention) Course

M010. Certificate Course in Endovascular Carotid Stenting

M011. Advanced Interventional Skills Courses in Pain Management

M012. Gynaecology Trainee Workshop

M013. Advanced Laparoscopic Course

M014. Clinical Practice Procedures (Basic): Assessment/ Ultrasound

M015. Obstetric Ultrasound Certificate Course

M016. Musculoskeletal Ultrasound Clinical Skills Certificate Course

M017. Urological Ultrasound (ultrasound for the kidney, bladder, scrotum and prostate)

M018. Gastrointestinal System Ultrasonography Certificate Course

M019. The Intermediate Emergency Ultrasound (EFAST)

M020. Echocardiography: Scan Plane and Measurement

M021. RACEplus (Rapid Assessment by Cardiac Echo plus)

M022. Intermediate Echocardiography Ultrasound Certificate Course

M023. Intermediate Abdominal Ultrasound Certificate Course

M024. Ultrasound-Guided Vascular Cannulation and Catheter Placement

M025. Abdominal Ultrasound Certificate Course

M026. Clinical Ultrasound Course - Transthoracic and Transoesophageal TEE

M027. Ultrasound of the Hepatobiliary-Pancreatic System Course

M028. Breast and Thyroid Ultrasound Clinical Skills Certificate Course

M029. Certificate Course in Aesthetic Medicine and Dermal Therapy

M030. Crisis Resource Management (CRM)

M031. Tele-Robotic Surgery (Radical Prostatectomy) Workshop

M032. Advanced Airway Management Course

M033. Bronchoscopy Skills Training

M034. Diagnosis and Treatment (Haematology and Oncology) Certificate Course

M035. Advanced Care-taking and Treatment Techniques for Alzheimer's Disease Course

M036. Spine and Articulation Pain Syndrome Workshop