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The Holomedicine[®] Association's Inaugural Summit

27 November 2021

Report





Introduction

On 27 November 2021, the Holomedicine® Association held its Inaugural Summit. This summit was organised as a global event, gathering speakers from Southeast Asia, Australia, Europe and North America to share how they apply Holomedicine® technology in their own work.

The Holomedicine® Association is the first global industry association for Holomedicine®, created to illustrate the innovation in the field of digital health and to help shape the debate around digital transformation. It consists of individual experts from medicine, science, technology, and policy. The Association works to build new methods for delivering mixed reality technologies in medicine and surgery, ensuring they have maximum clinical impact.

Holomedicine® describes applications which blend augmented, mixed, and virtual reality to allow for the practice and delivery of medicine through sensory camera technology. "Holo" is derived from hologram, whereby medical information such as MRI and CT scans, as well as ultrasound, microscope, and endoscope screens, are displayed as holograms. This is viewed through mixed reality glasses while, at the same time, the real-world environment remains completely visible.

Holomedicine® applications can create a 3-dimensional hologram image of a patient's anatomy, allowing the surgeon or medical professional to carry out multiple practices including surgical planning and preparation, telesurgery, and training to student physicians.

Due to the global scale, and the therefore greatly differing time zones, the summit was split into two sessions- this report covers both sessions. Starting in Singapore at 09:00, speakers from Southeast Asia and Australia came together and individually presented how they have been using Holomedicine® in their medical, educational, and technological work. Additionally, two panel discussions were organised, providing a platform to compare and exchange the developments and challenges the experts face. Session 2 gathered speakers from Europe and North America and saw a variety of presentations in the medical, industry, education and technological arenas.



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Session 1: Participants

Speakers and panellist:

Ms. Andrea Della Mattea (*President, Microsoft APAC*)

Dr. Yujia Gao (*Vice-Chairman & Director of Medicine, Science, and Technology, Holomedicine® Association*)

Dr. Eng Tat Khoo (*Engineering Design and Innovation Centre, NUS*)

Dr. Meong Hi Son (*Samsung Medical Centre, Sungkyunkwan University School of Medicine*)

Diomedes Kastanis (*Chief Technology Officer, Microsoft APAC*)

Prof. Alfred Kow Wei Chieh (*Department of Surgery, NUS*)

Prof. Kee Yuan Ngiam (*Chief Technology Officer, NUHS*)

Gary Stefano (*Associate Director Customer Support Services, University of Queensland*)

Moderation: Ng Kian Wei (*Data Scientist, NUHS*)

Secretariat: Kinga Wójtowicz, Maddie Reed



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Welcome address

Dr. Yujia Gao

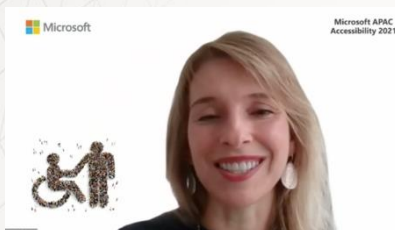
Vice-Chairman & Director of Medicine, Science, and Technology, Holomedicine[®] Association

Session one of the summit was opened by the moderator, Ng Kian Wei, who started by showing a video created by the National University Health System. This video illustrated that 'the future of healthcare is here' and promotes the use of mixed and extended reality in medicine.

In his introductory remarks, Dr. Gao explained that the objective of the Association is to promote the use of mixed and extended reality in medicine, whilst setting standards for safety, promoting harmonised public policies, addressing privacy concerns, creating funding streams and supporting the development of medical and scientific evidence.

Andrea Della Mattea- Keynote Speech

President, Microsoft APAC



Mrs. Della Mattea shared examples of technological applications that have been used during the pandemic, to depict that computing is being distributed and embedded in the real world, describing this period as a shift from digital transformation to a period of digital acceleration. She explained that in the next ten years, we will experience more digitalisation than we have over the past 40 years. She also projected that the healthcare industry is expected to spend more than \$256 billion on technology in the coming years.

Mrs. Della Mattea continued that Microsoft is helping healthcare organisations navigate the future through innovation and technology, teaming up with companies such as EG, to remotely monitor ICU patients, so medical professionals can manage more people with fewer resources. This improves workforce efficiency, decreases the need to use scarce PPE, and most importantly, decreases the spread of infection.

She also presented the life-changing applications the HoloLens has, using the example of patients on a remote island in Japan being able to receive real-time, virtualised, specialised medical care using the HoloLens. Mrs. Della Mattea also communicated the poignant message, that 'every company will learn to become a healthcare company', truly showing the central role health will take on in everyone's lives.

Dr. Yujia Gao

Vice-Chairman & Director of Medicine, Science, and Technology, Holomedicine[®] Association

NUHS Holomedicine[®] Programme: Mixed Reality in Healthcare- the Future of Integrated Medicine



Dr. Gao gave an overview of the history of extended reality in medicine, presenting the progress from virtual, to augmented, to mixed reality in healthcare. The aim of the NUHS Holomedicine[®] programme is to leverage mixed reality technology to enhance clinical capabilities, improve clinicians' experiences and patient outcomes. Dr. Gao elaborated on the different ways the HoloLens can be used by medical



practitioners, from pre-operative planning to intraoperative image guidance, and patient counselling. By using holographic devices, patients can better understand their condition, enabling better decision-making when it comes to the treatment programme. He ended his presentation with an inspiring message 'We believe this technology has the potential to transform the way we practice medicine and healthcare and make a difference to the next patient who walks through the hospital doors.'

Dr. Meong Hi Son

Samsung Medical Centre, Sungkyunkwan University School of Medicine

Holomedicine® for the Emergency Department

Dr. Son continued the session with the application of Holomedicine® in the emergency department setting. She highlighted the need for Holomedicine® technology in the Emergency Department to supervise training and aid younger doctors. She also pointed out one aspect in the medical world that is not often thought about is the time and effort it takes medical professionals to get from one hospital department to another. The use of a holographic device saves both patient and doctor a significant amount of time as virtual consultations can take place. This helps make the patient feel prioritised and increases the consulting abilities of doctors.



Dr. Son also emphasised that the application of holographic devices has been hugely meaningful during the pandemic, aiding in reducing transmission rates and therefore increasing protection for both patient and doctor.

Panel discussion

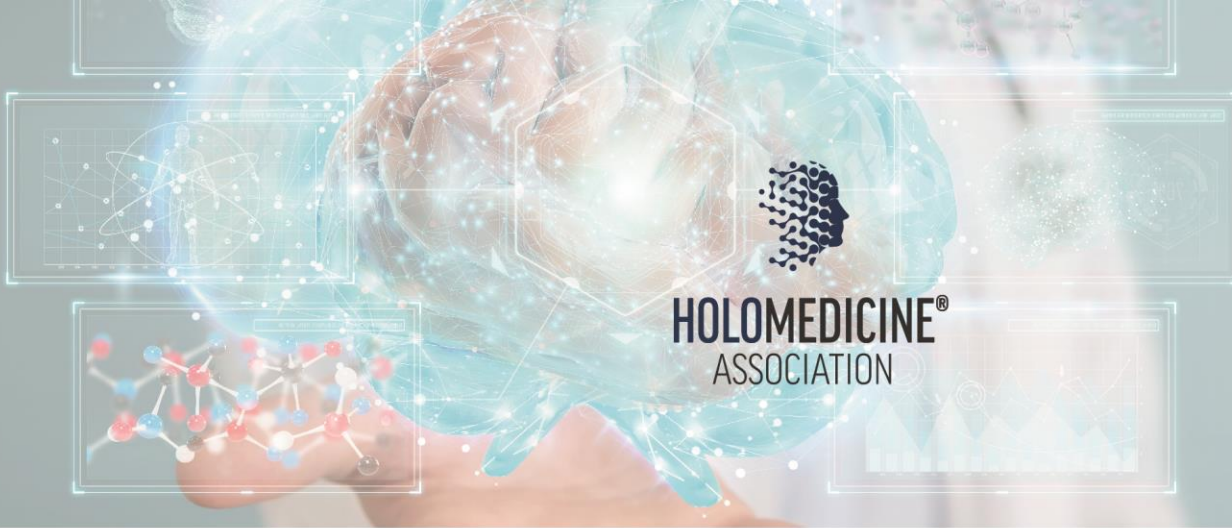
Driving a Paradigm Shift in Healthcare: Holomedicine® in Clinical Care

Prof. Kee Yuan Ngiam, Dr. Yujia Gao, Diomedes Kastanis, Dr. Meong Hi Son; Moderated by Mr. Ng Kian Wei, Data Scientist, National University Health Systems

The first panel discussion of the session focused on the use of Holomedicine® in clinical care and invited several speakers to share their views on a series of questions and topics. When asked about the projected uses of holographic devices in the healthcare industry, Prof. Ngiam responded first. Although they find themselves in the early stages of using Holomedicine® in hospital and community settings, the benefit this has for patients, training clinicians and providing them with guidance, especially during surgery, is already clearly visible.



Dr. Gao added that it is important to not try and force the technology, otherwise, the experience with it will not be optimal. The knock-on effect of a bad experience with Holomedicine® is that the uptake will slow, and make people view the technology as a gimmick. Therefore, it is important to be careful about which use cases to choose to work on, as it is important to maintain momentum and interest in the technology. He explained that at NUHS, they have found that the HoloLens has a specific niche and unique use area. One of the biggest benefits of using the HoloLens is that it manages to shift the cognitive load from one area to another. This is because surgeons no longer have to spend energy trying to mentally visualise a 3D scan of a given anatomic area. This visualisation ability takes years for clinicians to



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acquire. While experienced surgeons may not need to use the HoloLens, the technology provides less experienced clinicians to be able to deliver the same expertise and improve the overall patient experience.

Dr. Son compared Holomedicine® technology to the emergence of mobile phones. It is a technology that is inevitable but takes time for people to learn how to use it. Once a user has however learnt how to manipulate the HoloLens, for example, it is straightforward to use.

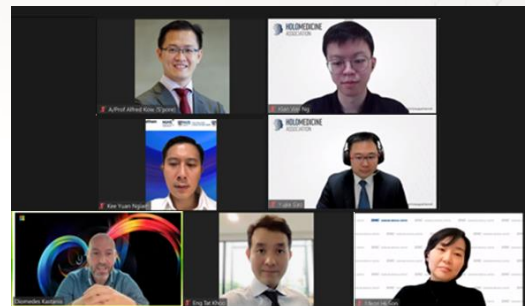
Mr. Kastanis continued the discussion by firstly congratulating everyone and emphasising the work of Dr. Gao, stating that the work the Holomedicine® Association is doing is having a real impact on the industry and allowing Microsoft to improve their work, especially through prolonging the idealisation of human-computer interaction. Mr. Kastanis also explained that Microsoft acquires new software platforms that can help with the user and patient experience when using the HoloLens, such as Lobe.ai. This platform allows users to upload pictures to a platform and label them. Once this has been done, the platform starts to train a machine learning model to identify these labels in new images. This software has significant applications for Holomedicine® and can improve current clinicians' concerns. For example, when trying to recognise tremors or seizures in patients through holographic devices, this software can aid clinicians in identifying the correct patterns and recognitions.



The panel discussion also covered the legal framework and challenges faced by clinicians in this area. Mr. Kastanis emphasised the need to define what compliance means in the context of this technology, and **Prof. Ngiam** presented two challenges: secure

data sharing and federated learning- securely aligning data sets and sharing these between sites.

There was also interest in learning about the grant opportunities available in Holomedicine®. Dr. Gao explained that various funding avenues are possible, depending on the industry and country. From the Association's side, the goal is to establish funding channels to receive sponsorships from industry partners or people interested in investing. He further mentioned that there are two possible streams of funding, directed funding, where sponsors can invest money into specific, ongoing projects, or undirected funding, where the Association receives the funding and channels this into projects.



The panellists were also questioned on whether Holomedicine® technology is FDA approved. Dr. Gao explained that the HoloLens itself is an enabler, providing a platform for clinicians to deploy solutions, and the need for FDA approval depends on which software is being used in conjunction with the HoloLens: some of these are FDA approved, some are CE marking approved. For example, in Singapore, the technology is CE marking and has been Class A approved. He added that it depends on the regulatory body in each country and what the intent of use is. He also included that one of the working groups of the Association is responsible for outlining existing policies and guidelines and creating new ones.

Dr. Son also reminded the audience that the technology should guide and convince regulators. New technologies have always had the responsibility

to show regulators how it works and make them aware of the astounding benefits it can bring.

Dr. Eng Tat Khoo

Engineering Design and Innovation Centre, NUS

Metaverse- Crossing the Bridge between Realities for Medical Simulation and Training



The second half of the session shifted the focus from the medical applications to the educational applications of Holomedicine[®] technology. Dr. Khoo presented various ways on how AR, VR and MR technologies are applied in the educational training of medical students. He provided multiple examples, for example using a robotic surgery simulator to allow for training and visualisation of how to conduct the procedure. Students can also be trained on how to conduct childbirth procedures using a childbirth delivery simulator. According to a survey outcome, 83% of students reported the simulation to be realistic and help them understand the procedure of birth delivery. A survey was also conducted on basic cardiac life support training using Holomedicine[®] technology, where 85% of students reported a positive experience using this new method of training. Dr. Khoo also demonstrated how students can be trained in improving their communication and assessment of patient skills using an AI-simulated patient - students can practice a verbal exchange and how to conduct a correct physical examination. Dr. Khoo demonstrated the wide application that Holomedicine[®] technology has in the education of students and provided clear evidence for the positive experience and outcomes of this method of teaching.

Professor Alfred Kow Wei Chieh

Department of Surgery, NUS

Revolutionising Medical Education and Training with Mixed Reality Technology using the HoloLens: The Way Forward

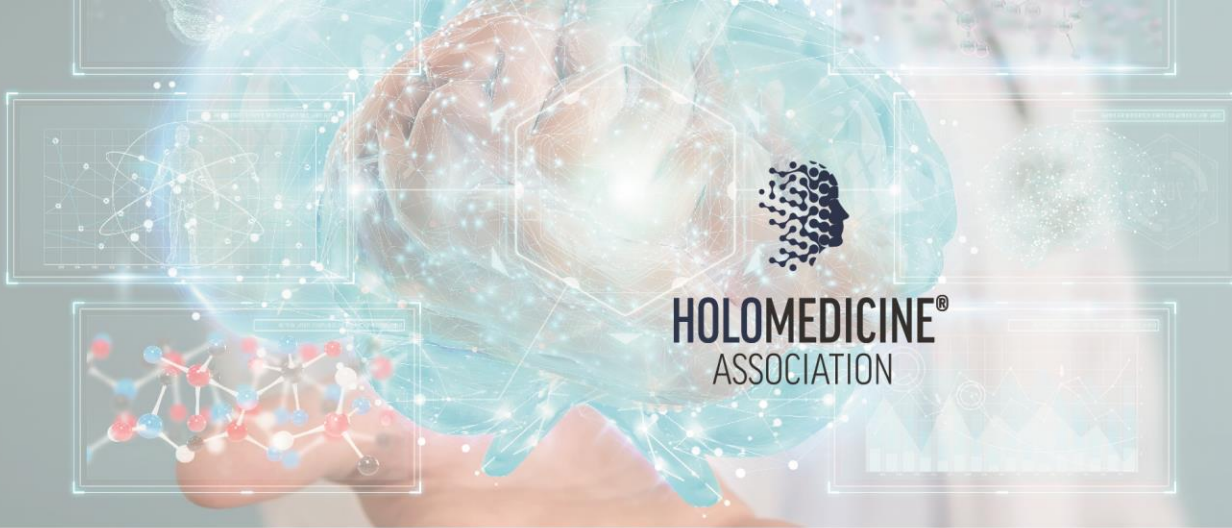
Prof. Kow provided further insight on the uses of Holomedicine[®] technology to advance medical education and training. He emphasised that it is important that AI is used to facilitate and enhance the way clinicians conduct surgery but that it does not replace the role of the surgeon.



He outlined the importance for clinicians to work closely with AI diagnostic systems to introduce AI into education and presented strategies for educational transformation, including

- Clear strategic intent- which allows for flexibility and recognises cultural complexities,
- Fostering participation and collaboration- where staff are involved across formal report chains and informal networks, allowing them to build a sense of ownership,
- Academic development- growing scholarly understanding and developing new models of teaching.

The main challenges presented were how to translate information into knowledge, given a large amount of content to be learnt, how to apply skills and knowledge in clinical practices, how to manage AI applications as well as how to maintain communication between doctors and patients. These aspects, namely relationships between doctor and patient, as well as the teacher and student relationship, were emphasised by Prof. Kow at the end of his presentation. He explained that AI will not replace these relationships, but rather enhance them.



Finally, he stated that mixed reality in AI machine learning is a crucial part of the future, not only in training but to carry this forward into medical practice.

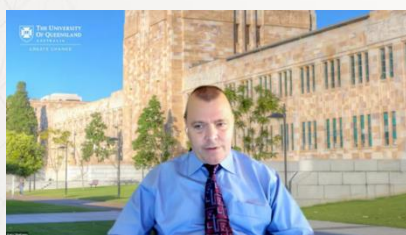
Panel discussion

Transforming medical education training with Holomedicine® technology

Dr. Eng Tat Khoo, Prof. Alfred Kow Wei Chieh, Gary Stefano; Moderated by Mr Ng Kian Wei, Data Scientist, National University Health Systems

The second panel discussion was introduced with a question regarding the potential barriers in medical entities in making the HoloLens a formal component into the curriculum for training residents and fellows.

Mr. Stefano started by explaining that it is challenging to get medical engagement and convince institutions to view this technology as educational and useful. His current focus is assessing the digital transformation and how this is going to influence teaching in the future. One misconception that Mr. Stefano clarified is that this technology is not a 'small scale thing' - medical programmes can be used to teach larger classes, but the difficulty is getting the momentum going on other courses. The greatest issue is the bureaucracy over IT being introduced and augmenting disciplines of such high levels. From his experience, medical programmes do not find IT technologies easy to adopt, and it is difficult getting an academic 'buy-in.' He concluded that the perceived usefulness and politics are the greatest barriers to getting the momentum going.



Prof. Kow added that NUHS has had more funding in place and has therefore seen better progress. He agreed that the initial steps were difficult since the

people on the ground were initially not enthusiastic about having this technology incorporated into training. He stated however that whilst COVID-19 is one of the biggest disruptors in our lives, it has also been a catalyst for the acceleration of its adoption. Prof. Kow also emphasised that is important to use Holomedicine® technology to augment teaching rather than letting it take over. Finally, he explained that an additional application of using the HoloLens in education is that if students are taught during their training, the hope is that they will take this forward into their medical practice and thus pass the importance of using this technology down to future trainees. This, therefore, creates organic growth and builds up a self-sustaining eco system.

The panellists were then questioned on the strategic plans they would like to see in place to motivate medical universities and residency training programmes to accept and use the HoloLens as a valid and solid training tool in their curriculum. Mr. Stefano reacted by stressing the importance of a forum to see how other areas and other countries are progressing in the implementation of Holomedicine® technology. He also stated that seeing this progress would be empowering and increase motivation to further advance integration.

To the question on whether mixed reality would replace virtual- and augmented reality (AR) fully or whether each technology has inherent advantages that make them suitable to different situations, Dr. Khoo explained that both virtual- and mixed reality can be effective, are compatible and complement education. Virtual reality allows for an immersive experience, making students feel like they are getting a more 'real' experience, and it is also low cost. Mixed reality adds onto the uses of virtual reality, including context to actual simulations itself, and can be used on imaging data and scans. It also provides real-time feedback to users. One significant thing to mention with this technology is that whilst it brings data into the environment you are in, it also captures data-



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allowing for these data points to be used to train up the AI and improve the technology with every use.

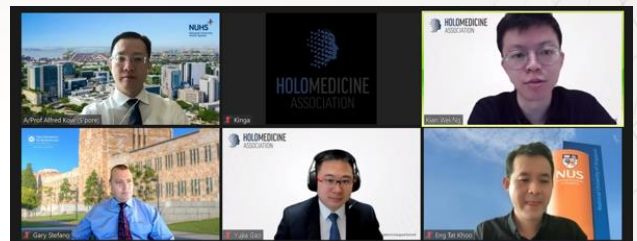
Mr. Stefano also added that one advantage of mixed reality technology is that it provides the students with a different learning experience and therefore different learning outcomes. He especially stressed that this is not a novelty, but rather something that students genuinely enjoy and therefore value.

Prof. Kow gave insight from his educationist perspective, stating that it is crucial to understand where exactly the learning gaps currently are and to implement and expand mixed reality technology in this area. It is important not to grow something for the sake of growing it simply because it is there. Instead, educators and medical professionals must understand how the technology can fit into the current gaps, build an eco-system around it and most importantly ensure that the technology is not the only tool being used. The implementation of such technology needs to be carefully triangulated and planned with the curriculum to ensure an enhanced learning experience, and subsequently, as Dr. Khoo also mentioned, analyse the data that is being collected through the use of this new technology and use it to further improve it.

The panellists were then questioned on the areas in which mixed reality has the most teaching potential. Prof. Kow stated that it has huge potential as long as educators and students understand how devices such as the HoloLens work and how it can be applied to teaching. It is incredibly versatile if guidelines and clear practices are followed, such as patient safety and confidentiality. For example, during the pandemic, only a limited number of students would have access to patients directly to carry out their training. If the patient agrees, a large number of students can have access to the teaching session through the use of the HoloLens, as the imaging can be projected to their screens at home. Prof. Kow elaborated that there are various levels of interactivity, such as practicing the use of the HoloLens with a patient to explain their

condition or practicing the examination of a patient. He remarked that ultimately the aim would be for each student to have their own device to practice on, and it to be seen as a piece of equipment as important as a laptop or a phone.

Finally, **Prof. Kow** stressed that Holomedicine[®] also has great implications for non-technical skills and ethical practice in medicine, where the HoloLens can be used to practice informed consent and train their professional skills. By using the HoloLens, simulated actors can be used by beginners to practice their scripts and learn communication skills. Importantly, these are also skills that students can practice in their own time and conduct self-learning.



Dr. Gao was questioned about any future plans the Holomedicine[®] Association has with regards to integrating mixed reality into medical training. He explained that one of the working groups the Association has foreseen is an education working group, which will gather educators in university- and hospital faculties and brainstorm together how mixed reality can be further applied to medical training at both undergrad- and postgraduate levels. He also introduced the plan to have a scoping review, from which subsequently different areas can be identified that need to be prioritised in line with the aim of the Association to get the best use of the technology. Additionally, the working groups will work at providing funding, and also non-monetary support to institutions, hospitals and universities, such as connecting these with relevant industry partners or authorities and accelerating the implementation of a variety of programmes.



Session 2: Participants

Speakers and panellists

Dr. Darshan Bakshi (*Co-Chief – Interventional Radiology, Clinical Assistant Professor – University of Calgary, Medical Director – Diagnostic Imaging Peter Lougheed Hospital Calgary Canada*)

Dr. Mark Cohen (*MD, FSSO, FACS Professor of Surgery, Pharmacology and Biomedical Engineering, University of Michigan*)

Dr. Robert Hannan (*Cardiovascular Surgeon, The Heart Institute, NCHS Medical Director, Quality, NCHS*)

Dr. Adel Helmy (*Associate Professor Neurosurgery, University of Cambridge Consultant Neurosurgeon, Cambridge University Hospitals NHS Trust*)

Dr. Igor Koncar (*Associate Professor at School of Medicine, University of Belgrade*)

Dr. James Macalister Kinross (*Senior Lecturer in Colorectal Surgery, Consultant Surgeon, Imperial College London*)

Mr. Sirko Pelzl (*Chairman, Holomedicine® Association*)

Dr. Neil Ralph (*Head of Technology Enhanced Learning at Health Education England/ Consultant Clinical Psychologist*)

Dr. David Rhew (*Global Chief Medical Officer & VP of Healthcare, Microsoft*)

Prof. Dr. Predrag Stevanović (*Associate Prof. of Anesthesiology, MD PhD at School of Medicine, University of Belgrade*)

Dr. Giuseppe Umana (*Fellow of the American College of Surgeons, Department of Neurology, trauma and gamma-knife center Cannizzaro, Hospital Catania, Italy*)

Joe Varrasso (*Head of Strategic Partnerships in Europe at Microsoft*)

Prof. Dr. Dirk Weyhe (*Director of University Hospital for Visceral Surgery, Carl von Ossietzky University of Oldenburg, PIUS- Hospital*)

Moderation:

Dr. Marc-Angelo Bisotti (*Director of Policy, Holomedicine® Association*)

Dr. Yujia Gao (*Vice-Chairman & Director of Medicine, Science, and Technology, Holomedicine® Association*)

Secretariat:

Kinga Wójtowicz, Maddie Reed, Benjamin Steens

Mr. Sirko Pelzl: Opening Remarks

Chairman, Holomedicine® Association

Mr. Pelzl opened the second session of the event and thanked the speakers for sharing their expertise. He expressed his enthusiasm by sharing the progress made in the medical world and reminded the audience that AR is already being implemented in many hospitals globally. Digital transformation and technology investment are areas that have already been transformed in the era of digital acceleration. Mr. Pelzl recalled the important roles hospitals have in leading the way in this technological development.



Following this statement, three hospitals were awarded the **Holomedicine® Centre of Excellence**, to acknowledge the pioneering work being undertaken by these institutions:

- The National University Health System, Singapore,
- The Pius-Hospital Oldenburg, Germany,
- The Nicklaus Children's Hospital, Miami, USA.

Dr. David Rhew - Keynote Speech

Global Chief Medical Officer & Vice President of Healthcare at Microsoft

Transforming Healthcare with Mixed Reality (MR)

Dr. Rhew gave a speech showing how MR can transform healthcare and improve its outcomes. He demonstrated several benefits of Holomedicine® technology that allows for visualisation.

For one, it adds a dimension of realism to the animations presented and allows users to perceive their environment in a novel way. Dr. Rhew elaborated that this concept has evolved from solely an entertainment area to additional ones, enhancing healthcare:

- during patient consultations, to enhance patient engagement and patient comfort by providing them with a better understanding of their condition;
- in a surgical setting, by using the technology to project a 3D holographic image of a patient's internal system; this allows for virtual collaboration and provides a framework as to how procedures can be better understood and prepared for. By having remote access to a shared image, the need for travel is removed and thus should significantly increase the availability of doctors at short notice;
- in the training and education of medical staff. The significance of this application of Holomedicine® technology was reinforced through the fact that students at Case Western Reserve University using HoloAnatomy, a virtual reality learning product created by the University with the HoloLens2, demonstrated a 50% higher retention rate with 40% less class time.



Dr. Rhew concluded the session by reiterating the importance of mixed reality and its potential to transform the way doctors care for patients and train clinicians around the world.

Dr. Dirk Weyhe

Director of the University Hospital for Visceral Surgery at the Carl von Ossietzky University in Oldenburg

Complex Cases in Liver Surgery - the Opportunities in Holomedicine®

Dr. Weyhe presented a number of case studies in complex liver surgery, explaining the importance of integrating Holomedicine® into everyday practice as well as the educational sector.

An early discovery when using Holomedicine® technology in the Oldenburg Hospital is that the quality



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of the imaging is dependent on the lighting of the room. To achieve the best results, the team installed RGB lighting, which allows the room to light up in any chosen colour, showing the innovation that is undertaken.

He also spoke about an ongoing project named VIVATOP (Versatile Immersive Virtual and Augmented Tangible OR Project), led by Bremen University, in collaboration with various institutions, universities, and companies. The project looks into research in preoperative planning and interoperative assistance using virtual, augmented and mixed reality – through the use of the HoloLens and Holomedicine[®] technology.



With the aid of visuals, Dr. Weyhe showed that the use of 3D models can be helpful in the pre-operative stage by overlaying an MRI or CT scan with the 3D model and achieving improved visual cognition. To further illustrate this point, a series of case studies were presented, in which Holomedicine[®] technology significantly improved or altered the surgical procedures of patients. In one example, a patient seeking a second opinion had her treatment significantly altered: originally, she was told that 70% of her liver would have to be removed – upon reviewing her condition and applying Holomedicine[®] technology during pre-operative planning and intra-operative assistance, only 30% of the liver was removed.

Dr. Weyhe also elaborated that Holomedicine[®] has a meaningful impact on the teaching and training of doctors and students and concluded by stating that the first experience with the "the HoloLens in complex liver surgery" showed great intraoperative support and a reduced risk of complications. It improved the focus of the entire surgical team, enabled effective training on

realistic procedures for patients and improved patient safety in complex procedures.

Dr. Giuseppe Umana

Fellow of the American College Surgeons, Department of Neurology, Cannizzaro Trauma and Gamma Knife Centre, Catania Hospital, Italy

Testing Augmented Reality (AR) for Neurosurgical Daily Use

Dr. Umana gave a presentation on the experimentation of AR for everyday use in neurosurgery by presenting a use case that took place at NYC-MISS 2020 (an event that provides a comprehensive overview of new and less invasive techniques with and without stereotactic navigation for the operative treatment of spinal disorders) with the goal of investigating and comparing the usefulness of advanced multimodal navigation tools intraoperatively in complex spine surgery revision.



Dr. Umana shared a case study on a woman with diparesis, paraplegia, and mental confusion and how Holomedicine[®] technology was applied to assist in the procedure. Dr. Umana gave a detailed explanation of the procedure and how the team achieved the desired results thanks to the use of MR technology, which allowed the team to achieve detailed accuracy in positioning the prosthesis. This case study was widely recognised by ultimately placing second in the NYC-MISS 2020.

Dr. Umana indicated plans and the medical areas in which Holomedicine[®] technology could be taken up:

- Informed consent (medical liability costs could be reduced with the possibility of sharing radiological images with families through informed consent)
- Neuroanatomy

- 📄 Clinical trials (use of hardware and software devices)
- 📄 Remote monitoring and mentoring
- 📄 Rehabilitation (exoskeletons for early post-operative standing made possible by MR to accelerate recovery, with psychological support through 3D images to present the case to the patient).

Panel discussion:

Holomedicine®: The Next Frontier of Medical Technology

Prof. Dr. Dirk Weyhe, Dr. Giuseppe Umana, Dr Adel Helmy, Dr. Marc-Angelo Bisotti; Moderated by Dr. Yujia Gao

The moderator of this session, **Dr. Yujia Gao** opened the discussion with a question regarding the main challenges of using MR in soft tissue surgery (e.g., liver and pancreas) versus reconstructive surgery (e.g., orthopaedic surgery). Dr. Weyhe responded by citing the example of the placement of liver during surgery, which is done manually, and therefore in comparison to automatic placement suffers from a lack of precision. Research into automatic placement is the next step for research, Dr. Weyhe explained.



Dr. Gao continued to ask the panellists about their views on the uses of 3D printing and whether MR technology will replace 3D printing or whether these technologies can have a symbiotic relationship.

Dr. Adel Helmy (Associate Professor Neurosurgery, University of Cambridge Consultant Neurosurgeon, Cambridge University Hospitals NHS Trust) explained that in his unit 3D printing has two uses: firstly, in operative planning and modelling, and secondly it is used for manufacturing prostheses specified to patients' scans. He explained that from a preoperative perspective, AR could replace the need for physical models, as these models ultimately have no useful

function during the surgery itself. Dr. Helmy explained that there is room for using 3D printing and AR and MR to complement one another, but ultimately stated his belief that there will be a shift away from physical models to in silico modelling (computer modelling).



When asked about the technology of neuronavigation (computer-assisted technologies used to help guide surgeons during neurosurgery) and whether MR will also replace this technology, Dr. Helmy stated that this shift away will need to happen, since AR is an intuitive technology, and thus easier to use. AR will also shift from use in specialised settings to more widespread applications. Importantly, Dr. Helmy raised the point that this shift is a technical one and will be led not by clinicians but rather by engineers, data scientists and programmers. This remark reinforces the value of the different working groups the Holomedicine® Association will create, as it shows that the development of Holomedicine® technologies is a cross-disciplinary combined effort.

Dr. Umana added that once more tools are made available with which MR can be used, this will lead to new approaches with which MR can be applied in a clinical setting. He used the example of a percutaneous procedure (access to inner organs or tissue via a needle puncture rather than an open approach, in which these organs or tissues would be exposed), wherewith the use of MR, doctors can carry out an open surgery without having to do any invasive procedures. Once this application of MR technologies is happening in the operating theatre, further development happens as clinicians can identify gaps in other fields where MR technology can be applied.



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Dr. Gao asked Dr. Weyhe on his opinion as to whether Holomedicine[®] and MR technology is ready to enter the operating theatres as a more ubiquitous and widespread use during surgeries, and what some of the biggest challenges that this technology may face before it can become the standard practice. Dr. Weyhe replied that the current focus should be put on using these technologies in studies to ensure their optimisation.

Dr. Gao continued the panel discussion with a question regarding the applications of Holomedicine[®] and MR in neurovascular anatomy training for residents and junior trainees. Dr. Helmy listed areas in which he saw specific applications:

- ▶ Accurate visualisation, which is not achievable through visuals in textbooks or angiograms,
- ▶ Preoperatively, to assist in the mapping of vessels in procedures such as aneurism surgery,
- ▶ Assist in the planning of procedures, by allowing for navigation of complex legions and assessing the sequence in which vessels should be approached.

The issue of reliance on these new technologies was also discussed, and the risks of these technologies failing intraoperatively when used by less experienced surgeons. Dr. Umana responded that surgeons have a full understanding of the anatomy and a surgical strategy before starting a procedure. Even when using AR tools, surgeons must continually assess the accuracy of the navigation. Although navigational tools are useful for a surgeon, they do not rely on them.

Finally, Dr. Gao relayed a question asked by the audience regarding the concerns of data, patient and cyber security, with more and more information being stored on the cloud and technologies, such as the HoloLens allowing for remote access, remote assistance and data sharing globally. Dr. Bisotti answered this question by firstly stating that it is in everyone's common interest to not harm or give the impression that these concerns are not of interest to those who use these technologies. This remains a daily concern for

everyone involved and working towards solutions is a step that any hospital or practice takes.

Dr. Mark Cohen

MD, FSSO, FACS, Professor of Surgery, Pharmacology and Biomedical Engineering at the University of Michigan

Applications of XR Technologies for Surgical Skills Simulation, Teaching, and Improved Clinical Care Delivery

Dr. Cohen gave a presentation on the use of MR technologies for remote rounds, medical education, and international exchanges. The current activities of the University of Michigan, Centre of Surgical Innovation/Centre Initiative for Medical and Surgical XR (CMSXR), were presented: setting up a partnership with Imperial College London and Alder Hay Children's Hospital in Liverpool, and a variety of industrial collaborations, including Microsoft, ApoQlar, and Medtronic.

Dr. Cohen explained that work that is undertaken at the University of Michigan is motivated by the need to develop and apply MR technology tools to improve classroom and bedside teaching, while reducing exposure, risk, and PPE use in the clinical environment, improving mastery and maintenance of skills for trainees and providers, as well as create a more immersive environment to share expertise worldwide.



One of the unintended effects of COVID-19 on medical education was that students were taken out of the hospital environment and given virtual courses for long periods. This created disparities in clinical experience and education, difficulties in not being able to make routine rounds with patients, getting bedside feedback and interacting more easily with faculty and facility staff on the wards. As these issues could be addressed by the



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presence of MR technologies, a MR tele-rounding pilot using the HoloLens laptop was created.

Dr. Cohen stressed that a new Centre for Surgical Innovation has been opened with the aim of providing a collaborative space for industry-academia partnerships for surgical simulation training, AR/XR applications in clinical care, education and simulation and tissue engineering, 3D printing and device prototyping.

Dr. Cohen also highlighted that the project, entitled 'Mixed Reality in Medical Education and Practice', won the Provost's Teaching Innovation 2021 Prize, and that a new industry-academia partnership creating AR innovation grants for medical students and residents to develop new competency-based assessments for procedure-based training using extended reality was set up. A discussion on extended reality technology was also held at an event called the "Inaugural XR summit", to which over 1000 people from 31 countries registered.

Dr. Cohen also presented the Emergency Preparedness Response course, designed to provide learners from all walks of life with a series of steps they can take to stabilise or assist a person they witness in several types of life-threatening emergencies.

Dr. Cohen finally presented a collaboration with ApoQlar to develop the use of the novel 3D holographic image reconstruction to look at better ways to evaluate acute aortic disease and concluded the session by presenting the next steps they will take to grow their medical extended reality initiative, including further collaborations with industry partners, new clinical and research pilots, further learning and training modules.

Dr. Darshan Bakshi

Co-Chief of Interventional Radiology, Assistant Clinical Professor at the University of Calgary, Medical Director of Diagnostic Imaging at the Peter Lougheed Hospital in Calgary, Canada

Holomedicine[®] in Imaging and Imaging Guided Minimally Invasive Procedures

Dr. Bakshi presented the uses of Holomedicine[®] in interventional radiology and diagnostic imaging and explained how it is used in practice.

Dr. Bakshi guided his reflections under 3 main themes:

- Image-guided minimally invasive procedures and the role of Holomedicine[®].
- Preoperative – the clinical benefit of using holographic imaging in preoperative planning (Holo FEVAR study).
- Intra-operative - the clinical benefit of using holographic imaging (Holostream study).

The first theme focused on the use of holograms in creating a more intuitive understanding of imaging anatomy and achieving higher accuracy during procedures. Holomedicine[®] has undoubtedly increased the visibility and safety of clinicians' own actions. Dr. Bakshi provided the audience with several examples, showing how the use of Holomedicine[®] aids minimally invasive procedures.

Dr. Bakshi provided an example of a Pulmonary AVM (Arteriovenous Malformations) Embolisation procedure (procedure in the lung). The challenge in this procedure lies in finding the exact position. With the use of 3D, surgeons can have an overview of the anatomy, which is part of the pre-planning procedure. With this visual aid using holographic imaging, surgeons are able to tell which angle will be most effective for the operation.



To illustrate the second theme, Dr. Bakshi showed how Holomedicine[®] technologies have been useful for surgical planning in fenestrated endovascular aneurysm repair (FEVAR). An ongoing study for the pre-planning stage of the above-mentioned procedure compares the traditional 2D rendered images with 3D printed models and compares these methods to using holographic images. The findings of this study are to be collected and assessed once enough testing has been done.



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Dr. Bakshi provided a clear overview of the uses of Holomedicine® in the intraprocedural stage. He explained that the device VSI streamer, made by ApoQlar, allows for livestreaming of X-ray images or ultrasound images onto the operators of the HoloLens screen, providing ergonomic advantages, as well as helping to perform the procedure without having to manipulate the set-up of the room significantly. The main objective was to evaluate the usability of the VSI Streamer software by comparing the effect on interventional radiology procedures performed with and without the software. Secondary objectives included:

- Evaluate Radiographer usability of VSI streaming software
- Develop suggestions for future research studies to assess the safety and efficacy of VSI Holomedicine® software during other interventional radiology procedures
- Evaluate the impact of VSI streaming software on room setup time, procedural time, and fluoroscopy time
- Assess the feasibility of remote collaboration by real time image transmission between remote devices through 3D telemedicine.

Dr. Bakshi concluded his presentation by stating the next steps in this study, including analysing the data from the study and publishing the results, retesting future iterations and developments, and setting up collaborative trials to progress together.

Dr. Robert Hannan

Cardiovascular Surgeon, Heart Institute, NCHS Medical Director, Quality, NCHS, one of the award-winning Holomedicine® centres of excellence

Enabling Surgeons, Empowering Patients

Dr. Hannan began his presentation by thanking the Holomedicine® Association for its collaboration and emphasised his belief that the Association will revolutionise the world of healthcare with MR. Dr. Hannan showed 2 videos made in 2021, one made at the University of Florida and the second at Nicklaus Children's Hospital. The first focused on the effect of

teaching 134 students at the university using the synergy between the 3D model and the HoloLens in conjunction with the VSI ApoQlar application. The video depicts the enthusiasm and reception of the medical students for the synergy that the use of these technologies allows them to achieve.



Following the video, Dr. Hannan introduced two engineers working alongside him in the hospital, Thomas Haglund and Muhanad Shraiteh, explaining their role and contributions to the research and development efforts of Holomedicine®. Over recent years the team has focused further on all aspects of Holomedicine® and virtual models since 3D printed models take a significant amount of time to be produced. Mr. Haglund illustrated a series of advantages that come with the use of the HoloLens2, including bringing patient information directly into the HoloLens application as well as the potential for surgical planning and communication with the patient through the technology. Mr. Shraiteh pointed out that one of the biggest impacts this technology will have is that it will leave no patient behind. He provided several examples, such as a hospital in Sub-Saharan Africa where an estimated 70% of the medical devices donated by the World Health Organization were not used, due in large part to a lack of provided technical training. With these innovative technologies, however, experts can be easily reached and provide training remotely to medical professionals around the globe, putting these devices back into use.

The second video, which tells the story of a 14-year-old girl, suffering from a cardiac murmur, and demonstrated how this technology helped her, not only during the medical pre-planning, but also during the operation, to ensure the patient's safety. The patient was



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able to understand her heart condition for the first time, by using the HoloLens herself and seeing her heart via 3D imaging. This allowed doctors to better explain the condition and provided the patient with reassurance, increasing her comfort during her in-patient stay.

Panel discussion: Holomedicine[®] and the Future of Immersive Anatomy

Dr. Darshan Bakshi, Dr. James Macalister Kinross, Joe Varrasso, Dr. Neil Ralph; Moderated by Dr. Marc-Angelo Bisotti

Dr. James Macalister Kinross, Senior Lecturer in Colorectal Surgery and a Consultant Surgeon at Imperial College London, opened the discussion by explaining how the adoption of mixed and augmented reality technologies were rapidly scaled during the pandemic, in order to continue to provide sufficient patient care in hospitals.



These technologies are especially crucial in continuing the education and training process of young doctors and medical students, but also needed to be implemented to keep providing enough work force. A particularly effective application pointed out by Dr. Kinross was the use of these sophisticated technologies for the assessment of their students and the continued measurement/monitoring of their performances.

Dr. Neil Ralph, Head of Technology Enhanced Learning at Health Education England/ Consultant Clinical Psychologist, took the floor to present his work in supporting the supply of the work force across medical, non-medical and other roles in the healthcare system to make sure they have the right skills and knowledge. His particular interest lies in understanding how his department can facilitate and enhance the way that education and training are done through learning

technologies and simulation-based approaches to education.



Dr. Ralph explained that a particular interest of Health Education England is to build relationships with colleges and bodies in order to join the 'pivot point' and implement new technologies at scale. Additionally, this joint network would also help to understand how these new technologies influence the policy around education and training. The UK, as is similar globally, is faced with a burnt-out workforce, yet it is vital for these young professionals to continue their training trajectory.

One of the key focal points of HEE, therefore, is to make this pivot in technological advancement happen, investing at scale and providing access to equipment and applications to be used in practice. Dr. Ralph emphasised the importance of equity in this process, to allow for this technology to be implemented across England and the system, rather than being accessible only to those institutions with deep pockets.

Dr. Bisotti noted the importance of funding, and how the focus lies in implementing this funding sustainably. For the Holomedicine[®] Centres of Excellence this was an important part of the selection process, having to provide not only evidence of secured funding but also the ability to sustain the programme, create research evidence, further their avenues, create more interest and further the funding streams.

Mr. Joe Varrasso, Head of Strategic Partnerships in Europe at Microsoft, continued to elaborate on Microsoft's involvement, relating to their close work with the NHS since the start of the pandemic. Microsoft, like many other organisations, has been working on supporting the introduction of necessary technologies that can significantly help medical professionals in their



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work. Mr. Varrasso explained his engagement in putting together a consortium of partners to address a number of challenges, such as the solution to the lack of ventilators, and how to increase the speed of knowledge transference to the work force in manufacturing, to speed up the overall process of the production line. Another work stream focuses on the applications of these new technologies in the clinical space, as also demonstrated by Dr. Ralph and Dr. Kinross. Mr. Varrasso also reflected on Dr. Rhew's speech and Microsoft's mission to create a health cloud that would facilitate access to medical data.



Mr. Varrasso explained that it is necessary to be able to share best practices, which is one of the reasons Microsoft chose to partner with the Holomedicine® Association. The Association provides an independent forum that can encourage and connect healthcare professionals globally and enable them to share best practices. He concluded by sharing that the clinicians who have been using this technology, continuously discover novel ways to apply this technology across the system and across various medical disciplines.

Dr. Bakshi stressed that Holomedicine® must play a crucial role in distance learning. Where there is a lack of qualified surgeons, often patients must be transferred great distances to have access to the right expert. Holomedicine® technology would be useful in these cases, empowering emerging physicians and surgeons to be able to perform these procedures, aided remotely by highly qualified physicians. The capability to have access to personnel virtually would be a major step forward for the healthcare industry.

Dr. Bisotti posed a question on the biggest challenges in how to best provide more evidence, so that these new

technologies can be integrated into routine practice. **Dr. Kinross** stated that the most important aspect to consider is to learn from previous technologies that have emerged in the medical field and avoid making the same mistakes. Clinicians and educators need an evidence base to adopt these technologies, especially if they are costly, in order for these to have a direct benefit to patients and students alike. Dr. Kinross concluded that in order to provide this evidence, it is not always required to perform trials, acknowledging that in specific cases, such as the high-risk interventions presented by many speakers during the summit, this is important. However, he explained, the Holomedicine® Association is able to provide a platform to build cohesive registries and create new ways of using the cloud to share best practices globally. The biggest barrier in this process will be creating the governance and ethical frameworks that will allow for this data and information to be shared.

Dr. Ralph was questioned on how to go about gaining public support for new technology and its implementation. He stated that it is important to have an open line of communication with people and share the evidence that is collected along the process of implementation. He also stated that the technologies should not simply be handed to people, but instead, a platform needs to be provided for people to connect and exchange views, set up a framework for support and push investment into other areas that support the overall process, such as the technicians, IT departments, and the education faculties.

Finally, Dr. Bisotti questioned **Mr. Varrasso** on the ability to learn from AR solutions in areas that extend beyond medicine. Mr. Varrasso provided an example of the use of AR in the manufacturing process, where employees are provided with remote assistance or where this technology is used for training and learning how to use a new piece of equipment. Mr. Varrasso reflected that the process used in the manufacturing industries is paralleled to processes in the medical industry and could be used to compare and learn from one another.



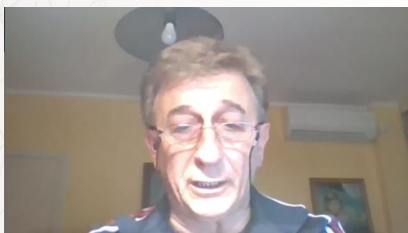
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Closing Session: A New Vision of Healthcare: Live Cross-border Cooperation in Anaesthesiology and Vascular Medicine

Prof. Dr. Predrag Stevanović

Associate Prof. of Anesthesiology, MD PhD at School of Medicine, University of Belgrade

A final session presented the implementation of the HoloLens in Belgrade's education programme. The team faced a similar experience to many other clinicians, the onset of the pandemic and the subsequent lack of access to the workplace. With the use of the HoloLens, clinicians were able to communicate with their colleagues and discuss patients' treatment options, without having to take any risks. Patients who were in red zones of emergency departments (requiring treatment for severe conditions) were able to be assessed remotely with the use of the HoloLens during the pandemic, and overall reduced the time these patients spent in the red zone department by 32%.



Additionally, due to the lack of work force during the pandemic, many doctors working in the red zone were younger, less experienced colleagues. The use of the HoloLens thus allowed doctors to communicate with one another and with the patients and resulted in better decision making.

Dr. Igor Koncar

Associate Professor at School of Medicine, University of Belgrade

Dr. Koncar concluded the session by demonstrating how the HoloLens was used to plan a complex procedure where imaging was crucial to the preparations. A recording was played showing the cross-border collaboration between doctors from Serbia and Malta, who performed real-time cooperation using the HoloLens. They were able to consult a colleague in Malta and show the patient's anatomy to a highly realistic standard, allowing him to effectively contribute and provide advice as to how to best perform the procedure. The collaborative team were able to effectively highlight the real value of the HoloLens and showed how MR technologies are coming together to significantly improve patient outcomes.



Dr. Bisotti concluded the summit by thanking all participants for their great contributions. Dr. Bisotti was pleased to hear that some colleagues were already asking to attend the next meeting. The way HoloMedicine® technology is making a difference to people's lives and patient outcomes can only encourage the Association to move forward and continue a path of the health technology revolution and thanked the audience not only for their participation in session, but also for the significant changes they are trying to make in the world.



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Thank you!