#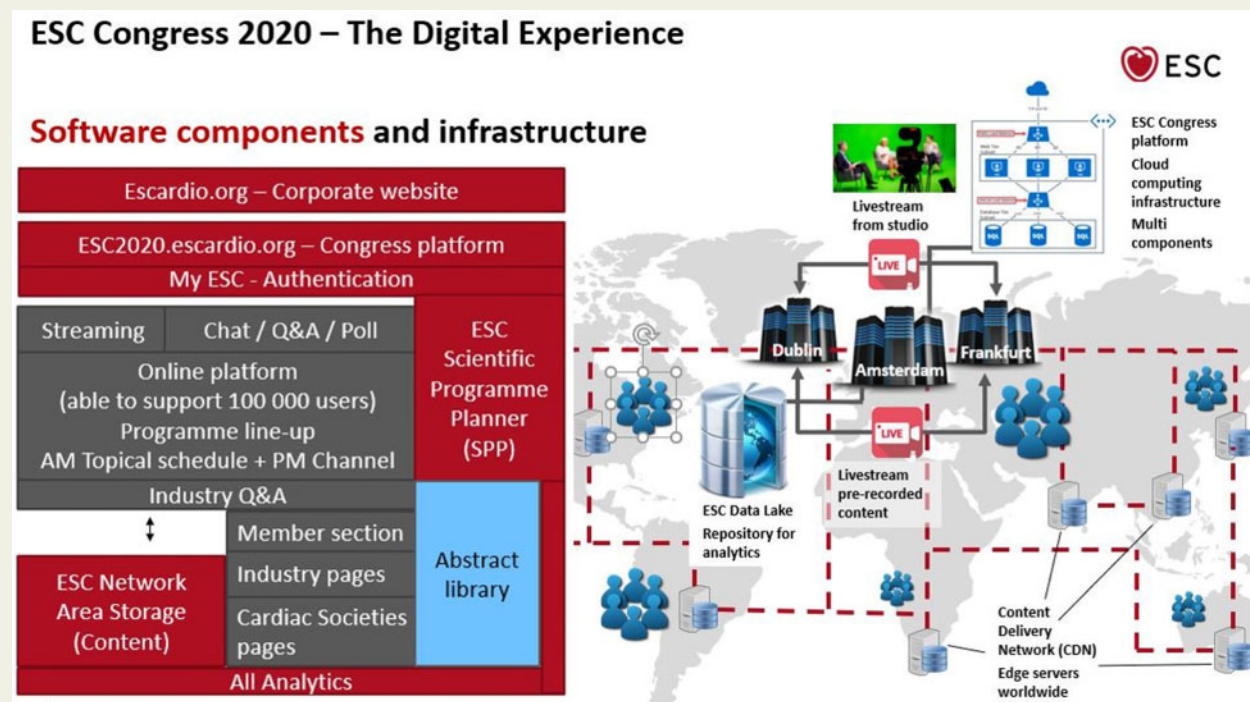 Digital transformation of major scientific meetings induced by the COVID-19 pandemic: insights from the ESC 2020 annual congress

Marco Roffi [1]*, **Barbara Casadei** [2,3,4], **Christine Gouillard**[5],
Nata Nambatingué[5], **Ghislain Daval**[5], **Isabel Bardinet**[3], and **Silvia G. Priori**[6,7,8]

[1]Division of Cardiology, University Hospitals, Rue Gabrielle-Perret-Gentil 4, 1211 Geneva, Switzerland; [2]Division of Cardiovascular Medicine, BHF Centre of Research Excellence, John Radcliffe Hospital, University of Oxford, Headley Way, Headington, Oxford OX3 9DU, UK; [3]Cardiovascular Medicine, British Heart Foundation,Greater London House, 180 Hampstead Road, London, NW1 7AW, UK; [4]Biomedical Research Centre London 2, 162 City Rd, London EC1V 2PD, UK; [5]European Society of Cardiology, The European Heart House, 2035 Route des Colles, Les Templiers, CS 80179 Biot, 06903 Sophia Antipolis, France; [6]Division of Molecular Cardiology, Istituti Clinici Scientifici Maugeri, IRCCS, Via Salvatore Maugeri, 10, 27100 Pavia, Italy; [7]Department of Molecular Medicine, University of Pavia, Via Carlo Forlanini 14, 27100 Pavia, Italy; and [8]Fundación Centro Nacional de Investigaciones Cardiovasculares, C. de Melchor Fernández Almagro, 3, 28029 Madrid, Spain

As a consequence of the COVID-19 pandemic, the European Society of Cardiology (ESC) was forced to pivot the scientific programme of the ESC Congress 2021 into a totally new format for online consumption, *The Digital Experience*. A variety of new suppliers were involved, including experts in TV studio, cloud infrastructure, online platforms, video management, and online analytics. An information technology platform able to support hundreds of thousands simultaneous connections was built and cloud computing technologies were put in place to help scale up and down the resources needed for the high number of users at peak times. The video management system was characterized by multiple layers of security and redundancy and offered the same fluidity, albeit at a different resolution, to all user independently of the performance of their internet connection. The event, free for all users, was an undisputed success, both from a scientific/educational as well as from a digital technology perspective. The number of registrations increased by almost four-fold when compared with the 2019 record-breaking edition in Paris, with a greater proportion of younger and female participants as well as of participants from low- and middle-income countries. No major technical failures were encountered. For the first time in history, attendees from all around the globe had the same real-time access to the world's most popular cardiovascular conference.

* Corresponding author. Tel: +41 22 37 23743, Fax: +41 22 37 27229, Email: marco.roffi@hcuge.ch

Graphical Abstract

ESC Congress 2020 – The Digital Experience

Introduction

The annual congress of the European Society of Cardiology (ESC) is the largest cardiovascular meeting worldwide. The 2019 edition in Paris set a record attendance, with 33 510 registrants from 151 countries, 5154 exhibitors, and 410 journalists. The 2020 edition was supposed to start on August 29 in Amsterdam, but by the end of April, the Dutch Prime Minister announced a ban on large-scale events due to COVID-19 pandemic. Consequently, the ESC was forced to pivot the scientific programme of the ESC Congress 2021 into a totally new format for online consumption, *The Digital Experience*. The main challenge was to record and deliver the content to a worldwide audience. As it was rapidly understood that no single platform or supplier would have been able to support the project from an information technology (IT)/video production perspective, several individual components had to be put together to form a comprehensive platform. This required reaching out to a variety of new suppliers, including experts in TV studio, cloud infrastructure, online platforms, video management, and online analytics. We report challenges and opportunities encountered in the transformation of ESC Congress from an in-person to a record-setting digital event, hoping that this can be of help for the organization of future fully digital or hybrid major medical scientific/educational meetings.

Strategic decisions

The main challenge for the core team organizing the congress, composed of ESC leaders and ESC staff representing strategic fields such as scientific content, logistics, IT and video production, the main challenge was to not getting the content but content delivery. A variety of suppliers headquartered throughout Europe and North America with whom the ESC had never worked before were approached, including experts in online platforms, video management, and online analytics. A major strategic decision was to allow all participants to register to the congress for free. The goal was to reach out to the broadest possible audience. Funding was made available with the aim of surpassing current quality standards of digital meetings. This was considered an investment beyond the upcoming event because of the broadly shared belief that a digital component of medical meetings was there to stay, even after the COVID-19 pandemic was over. Obtaining early trust and financial support from industry partners for this new endeavour was critical in order to be able to launch the project. Everyone at the ESC embarked on the endeavour with enthusiasm, despite the limited experience gathered through few small digital meetings organized in the first half of 2020. The first communication about new digital format, via emails, social media, and web site, occurred in early May 2020, though at that time the modalities and

implications of pivoting the largest cardiovascular meeting into a digital event were largely unknown.

Adapting the structure of the scientific/educational programme for online consumption

The programme underwent extensive revision both in terms of number as well as structure of sessions (Table 1). The duration of presentations were reduced to 10 min and the number of slides limited to 18, while at previous editions of ESC Congress presentations would typically last 20 min and no restrictions on the number of slides was imposed. Session duration was reduced from 70/90 min to 30/40 min. In order to ensure the quality of the pre-recorded presentations, all presentations of the prearranged scientific and educational programme were assisted by a technician ensuring proper sound, image, and the length of the presentation. Abstract presentations were system-assisted, i.e. a robot step-by-step wizard system checked the length of the presentation and the number of slides. The scientific programme, which extended over 4 days, was divided in two portions. In the morning (according to central European summer time), pre-recorded content was released daily, organized by topic, and ran in parallel on 10 different channels, the so-called 'Channels by Topic'. From 2 p.m. to 6.30 p.m., session at highest profile such as Clinical Trials Hot Lines or featuring Clinical Practice Guidelines were broadcasted on a single live channel. Finally, video-on-demand content from the main programme as well as the abstract programme was released daily and available 24/7 on a virtual library (Figure 1).

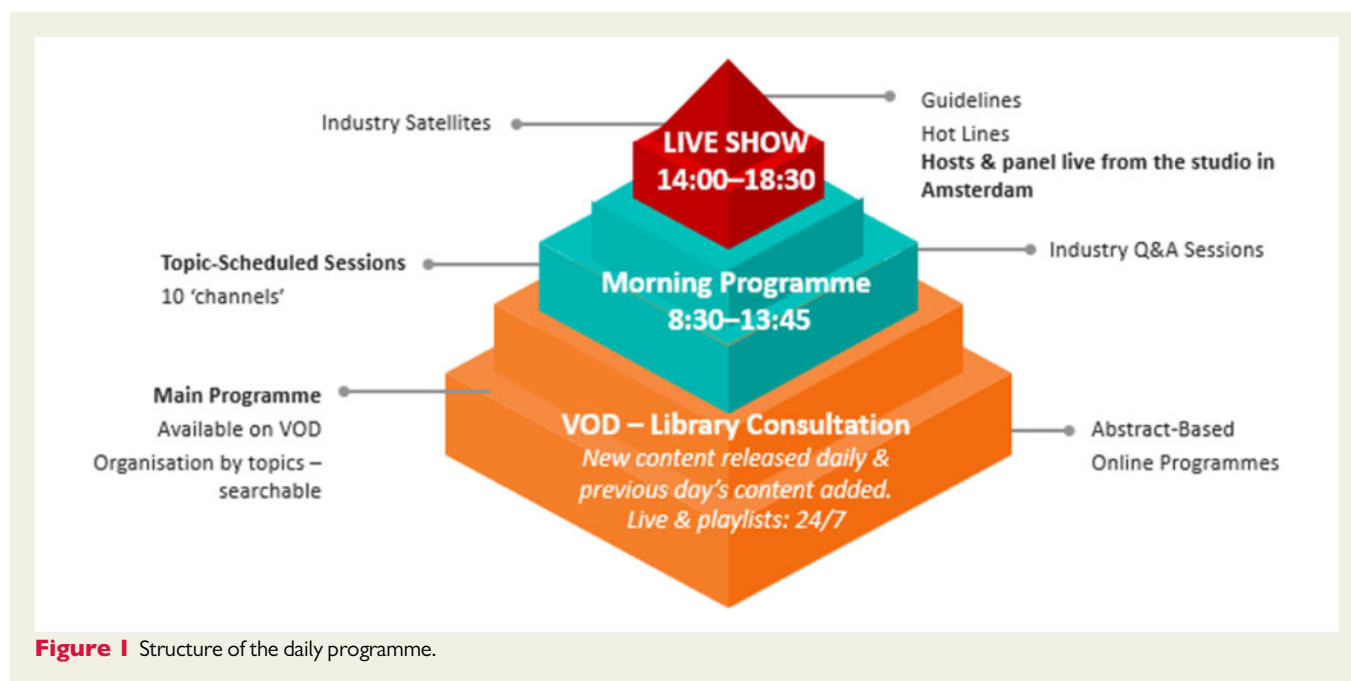| Table I Key figures of the scientific programme	
Total number of presentations	4087
o Recorded presentations	4042
– PPT voiceover, no technical assistance (e-posters)	428
– Recorded presentations with technical assistance (including abstracts)	1190
– Presentations within recorded webinars	168
– Presentations with recording crew at the speaker site	30
o LIVE presentations	45
– Guideline presentationsa	19
– Hotline trial presentationsa	13
– Discussant of hotline trial	13
Total number of sessions	561
o Scientific and educational sessions (recorded)	281
o Abstracts sessions (recorded)	259
o LIVE sessions	21
– ESC TV Daily Wrap-Up	4
– Hot Line trials	13
– New ESC Guidelines	4

[a]Those presentations were pre-recorded with a recording crew at the site of the speaker streamed LIVE embedded in the 3D studios in Amsterdam.

Multiple tools were put in place in order to foster interactivity of the online audience (Table 2). The first priority was to get interaction during the live sessions. For this to happen, the timing between the content and the interactive component next to the live feed had to be set to coincide, so that the conversation and survey next to the feed was the right one per the content that was being viewed by the user. This proved to be challenging, in particular in anticipation of the live sessions, which were sometimes shorter or longer than planned and for which the interactive component had to be reset in real time during the event. Second priority was the interaction in the abstract-based portion of the programme. To that purpose, commenting was enabled on the abstract and clinical case gallery to allow users to comment/ask questions. Presenters were encouraged to access their e-posters regularly throughout the meeting to address comments and questions from the viewers (Table 2).

In addition to the scientific and educational programmes, videos and intersession programmes were produced, featuring non-scientific yet informative content, such as ESC resources and educational opportunities or documentaries showcasing some of Europe's leading cardiovascular research centres (Supplementary material online, Video S1). Special lectures, such as Named Lectures, were recorded by a video crew dispatched to the home or office of the speaker. The Hot Line presentations, which included the highest profile late breaking trials, were particularly demanding in terms of organization. A video crew was sent to the presenter and green screen backdrops installed. Subsequently, the presenter were superimposed into the virtual 3D TV studios in Amsterdam. While the chairs and trial discussants were filmed live in a green screen studio in Amsterdam and embedded in the virtual 3D studio (Figure 2 and Supplementary material online, Video S2), the trial presenter did connect at the end of his/her green screen-recorded presentation via a video-conference tool to answer questions submitted via chat from the five continents. The incoming questions were triaged by a dedicated question moderator and submitted to the chair who formulated them to the presenter. An additional role was developed for experts acting as discussion forum animators to encourage scientific exchange on each day's 'Channels by Topic'. During the broadcasting of the session, chairs and presenters were asked to connect in order to participate to the discussion form, animate the discussion, and respond questions (Table 2).

The industry-sponsored portion of the programme comprised 55 morning Q&A sessions, consisting of a pre-recorded portion and a Q&A segment in which presenter were connected and exchanged with the viewers, and 8 Industry Live sessions, broadcasted in the live prime-time channel in the afternoon. Industry presentations were also made available to registered delegates as video on demand on the platform until 30 September 2020, before being uploaded for members on the website ESC 365.

The total number of session represented over 85% of the offer at ESC Congress 2019 in Paris (Table 1). A total of 700 invited faculty (-55% when compared with the previous year) from 47 countries (-33%) contributed to the programme. As time differences worldwide had to be taken into account, the featuring of high-profile sessions, including Hot Lines with the results of major clinical trials and the release of ESC Clinical Practice Guidelines, was limited to few

Figure 1 Structure of the daily programme.

Table 2	Tools for interaction		
Pre-recorded content	Chat/open discussion forum		• Tool to get users to engage with one another and feel the community presence during the event. • During the broadcasting of the session, chairs and presenters were asked to connect in order to participate to the discussion form, animate the discussion, and respond to questions. • Experts were appointed to act as discussion forum animators to encourage scientific exchange on each of the 10 Channels by Topic.
	Interaction options with e-poster presenters		Viewers had following options • to follow the presenter on Twitter • To 'like' the presentation • To download the poster • To leave a comment on the presentation Presenters were encouraged to access their presentations regularly to address comments and questions of the viewers.
	Surveys		Many sessions were followed by a quick survey to collect timely feedback on how users were enjoying their experience and the content they were accessing.
	Q&A sessions		Typically industry-sponsored sessions consisting of a pre-recorded portion and a Q&A segment in which presenter were connected via a video-conference tool and exchanged with the viewers.
Real-time produced content	Q&A mode		Questions coming in via chat were triaged by a dedicated question moderator and then formulated by the chairs to Hot Line trial presenters connecting via a video-conference tool during afternoon live sessions in the 3D studios in Amsterdam.

hours in the afternoon central European summer time. Overall, abstracts and clinical cases involved 3299 presenters from 81 countries.
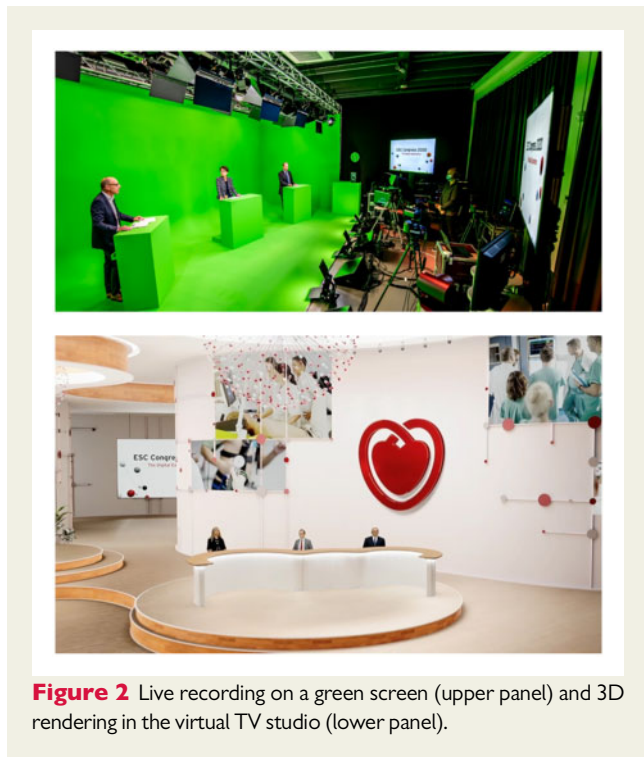

Figure 2 Live recording on a green screen (upper panel) and 3D rendering in the virtual TV studio (lower panel).

Managing the dissemination of the scientific/educational content

The very first challenge was to collect the content (slides, recording) for dissemination. Given the size of ESC Congress, it was not feasible to have the content live streamed from people's homes or offices in real time during the event. Therefore, the content was categorized according to its scientific/educational importance and the requirements in terms of recording/broadcasting (*Table 3*). To avoid participants feeling overwhelmed by the wealth of presentations, as previously mentioned the content was organized by topic (Channels by Topic). In addition, a user-friendly application was developed by the ESC to display the programme and allow searches by topic, session-type, or speaker. Users were able to bookmark sessions and have them available in a calendar format. During the event, sessions were flagged at the time they were happening and a direct link to the live feed was provided. Following broadcasting of a session, a link from the programme was available to access it as video-on-demand library 24/7. One month after the event, the entire content of the meeting was made available on the site web ESC 365.

Creating an IT platform

As on an estimation at the time the project was launched, the main criterion for the choice of the IT platform was the capability to support 50 000 simultaneous connections. The second selection criterion was the ability to follow a single sign on requirement in order to have the delegates logging in only once in order to be able to use all

Table 3	Recording/broadcasting modalities	
Pre-recorded content	e-Posters	E-Posters presentations allowed zoom-ins of preselected areas of the poster for easier discovery of image content. Presenters had the option of recording a 3-min commentary of their poster through an upload wizard.
	System-assisted presentations (abstracts)	Presenters uploaded the presentation with voice-over. Length of the presentation and the number of slides checked via robot-assisted wizard.
	Technician-assisted presentation (pre-arranged scientific/educational content)	Technician ensuring proper sound, image, and the length of the presentation.
	Pre-recorded sessions	Online set-up to recreate the traditional session format focusing on interaction between faculty. Technician-assisted with suppliers managing speakers, slides, and editing the final video for dissemination.
	Green-screen filming	Presenters were asked to welcome a camera crew which came to their home or place of work to record their presentations on a green screen background. Subsequently, the recording was embedded in a live studio transmission from the virtual 3D studio in Amsterdam.
Real-time produced content (live)	Commentaries and Q&A of hot-line trials, daily wrap-ups	Live broadcasting in a green screen studio in Amsterdam and image embedded in the virtual 3D studio.

features and navigate through the entire online event. As no standalone contactor was able to comply with the requirements, and in order not to be overexposed in case of failures, it was decided to sub-contract several suppliers, with the task of building multiple sub-platforms/components with high connection capacity—each powered by different technologies but well integrated and enabling a seamless navigation for end-users. The platforms functioned as a single entity and a single 'sign-on' was needed to navigate all of them. Cloud computing technologies were put in place to help scale up and down the resources needed for the high number of users at peak times.

The main supplier was a worldwide leader in video management platforms, offering multiple levels of security and redundancy for videos. The incoming feed from the studio or other streaming tools were pushed to two servers, one located in Frankfurt, Germany, and the other one in Dublin, Ireland, allowing for redundancy in the incoming feed to the player (Supplementary material online, *Figure S1*). The system processed the incoming feed and rendered an 'HTTP Live Streaming' (HLS) stream, enabled to adapt to the end-users capacity to receive a feed according to their internet bandwidth, i.e. a user with a low internet bandwidth would able to see the live feed in a lower image quality (i.e. lower resolution) but with the same fluidity as someone with a more performant internet connection. To complete the delivery chain, the streams were also distributed to the end-user via a content delivery network (CDN) to ensure quick access to the feed for any user, no matter their geographical location. For on demand video, the service was the same—HLS rendering of the video feed and a CDN network for the distribution—to ensure a seamless access also to the on-demand content, even when thousands of users accessed the same resource.

Following simulations, the infrastructure of the main supplier appeared to be very solid and able to support hundreds of thousands simultaneous connections, so the decision was taken to also build the main homepage of ESC Congress on that system. This required additional developments to get a homepage that was ESC Congress branded, had a navigation to the rest of the event, allowed a seamless interface between other parts of the event, and had additional features such as promotional space for sponsorship (Supplementary material online, *Figure S2*). Performance tests of the entire infrastructure prior to the event simulating 50 000 users on the platform were performed by a company specialized in web-performance. The platform had to be adapted several times to remove bottlenecks reaching 50 000 simultaneous connections with a correct response time (*Figure 3*). The ESC server infrastructure was moved to Microsoft Azure to benefit from cloud computing features such as availability and scalability. The IT and software costs accounted for 26% of the entire budget of the meeting (*Figure 4*).

For the abstract and clinical case presentations, ESC relied on an historic event management partner, which managed the speaker service centre, the content uploads and lecture rooms at previous editions of the congress. The provider had an existing e-poster library and an integrated system to produce voiceover as well as interactive posters. As the ESC programme management system and the supplier system had been integrated in the past, the additional IT development required for this portion of the programme was limited (Supplementary material online, *Figure S3*).

Finally, it was a goal for the ESC to provide a comparable fluidity and ease of support during the online experience as for in-person events. To do so, it was relied on an existing partner, which offered tools for online customer support. The ESC opted for a chatbot solution to address the more common and anticipated questions with the option to chat to an ESC agent for more specific questions (Supplementary material online, *Figure S4*).

Video production challenges

One of the most challenging technical aspects—involving a foray into uncharted territory—was the decision to make this online event look and feel more like a television production, i.e. interactive and much more visually engaging than what attendees had been experiencing in digital meetings. To convey this television feel, freelance
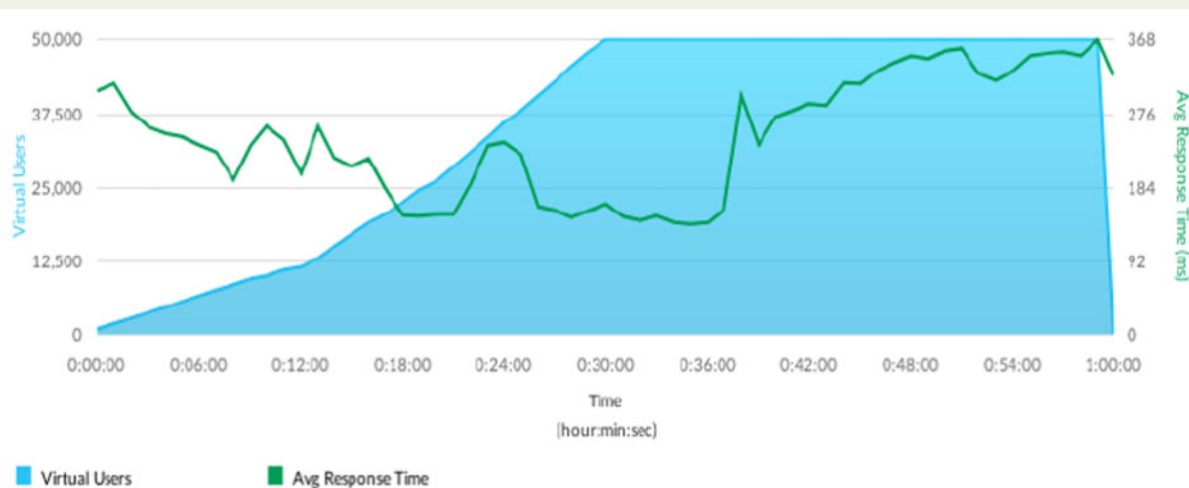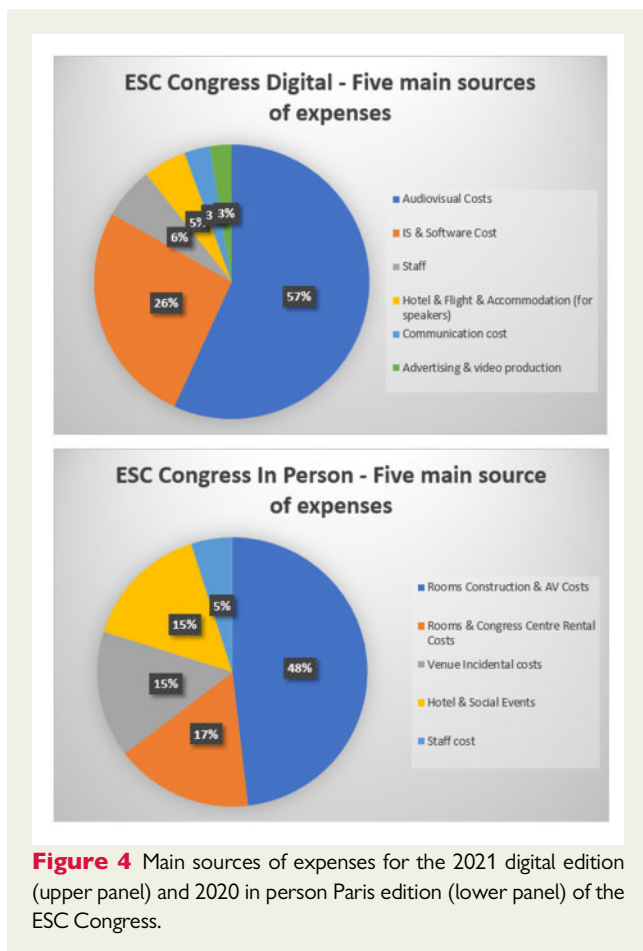

Figure 3 Virtual user vs. average response time according to a simulation by Akamai.

Figure 4 Main sources of expenses for the 2021 digital edition (upper panel) and 2020 in person Paris edition (lower panel) of the ESC Congress.

video crews were hired and dispatched to cities across Europe and North America to prerecord key presentations. In all, 43 green screen mini studios were created for the presenters in their homes or offices. This provided two noticeable advantages: first, presenters could appear standing, allowing for a more animated and energetic delivery; second, skyline images of their cities were inserted as colourful backdrops, adding to the global flavour of the meeting. During *The Digital Experience*, a vast 3D studio with even larger green screens was created in Amsterdam for the live afternoon segments of the programme featuring key opinion leaders who were able to travel (*Figure 2* and Supplementary material online, *Video S2*). The advantage of a vast green screen set—as opposed to a physical desk and studio—was that it allowed quick background changes by graphic artists since no physical construction was required. Two weeks before the event, sample video and photos were disseminated to promote the digital studio and to generate a worldwide buzz. It is notable that until the day the meeting started we did not know which of the key opinion leaders would be able to travel to Amsterdam due to changing COVID-related constraints. Accordingly, representatives coming from the United Kingdom and the city of Paris had to be replaced few days prior to the event. Finally, the total number of people allowed in the Amsterdam studios at any given time was also subject to local regulations and, potentially, to last minute changes. Best practices and standards of network television were implemented for both production and programming. Short (i.e. 20 s) videos with soundtrack were created as dynamic introductions to Guideline Sessions and Hot Lines. Similar short videos were featured in between pre-recorded programmes, promoting upcoming 'live' segments of the event or ESC educational resources. Audiovisual costs accounted for 57% of the entire budget of the meeting (*Figure 4*).

New promotional approach and press coverage

Since the digital event had no fees, deadlines or incentives for early registration, an innovative and fully integrated multichannel approach was required to entice people to sign up. Compared with previous in-person editions, major promotional changes included: the implementation of a paid advertising campaign on social media platforms; the engagement with a much broader audience, because major barriers to attendance such as cost, distance, time allocation had dissipated; the creation from scratch of engaging promotional material, as no photographs or videos from previous digital events were available; the option of targeting with promotion selected countries. Among the key lessons from this experience was the finding that organic social media provided a massive reach to new and younger audiences and paid social media was effective in driving both awareness and registrations with the flexibility to target selected countries. *The Digital Experience* successfully attracted media coverage. Although few journalists registered (204 as compared with 410 in 2019, -50%), 8337 articles were published on the congress (+28% as compared with the previous edition). Finally, the #ESCCongress-hashtag totalized 355 million impressions.

Participant's number and profile

The increase in registration as compared with the previous in-person edition of the meeting was almost four-fold (125 008 in 2020 vs. 33 510 in 2019). Equally impressive was the increase (+41%) in the number of countries represented (213 in 2020 vs. 151 in 2019) and the worldwide spread of people connecting during the event (*Figure 5*). Of particular note was the increase in participants from Central and South America: Mexico and Brazil were the leader countries in terms of registrations, accounting for 6.4% and 6.1% of the total, and 5 out of the 10 top countries in terms of registrations belonged to that part of the world (Supplementary material online, *Figure S5*). In comparison, in 2019 only Brazil with 3.4% of the participants was among the ten most represented countries in 2019, while Germany (7.8%) and France (6.0%) lead the way (Supplementary material online, *Figure S6*). The average age of delegates decreased from 49.2 years in 2019 to 40.6 years in 2020, while the proportion of people less than 40 years of age more than doubled, from 25% to 57% (*Figure 6*, adapted with permission). Finally, the proportion of female delegates increased from 33% in 2019 to 44% in 2020. ESC Congress 2020 was able to attract a vast new audience, with 62 007 of the registrants (50% of the total) being categorized as new contacts. New contacts originated from 195 countries/regions, 56% originated from Central and South America (56%) and 67% were under the age of 40 years. The proportion of congress registrants in training or students more than doubled compared with the previous year (31% vs. 12%).
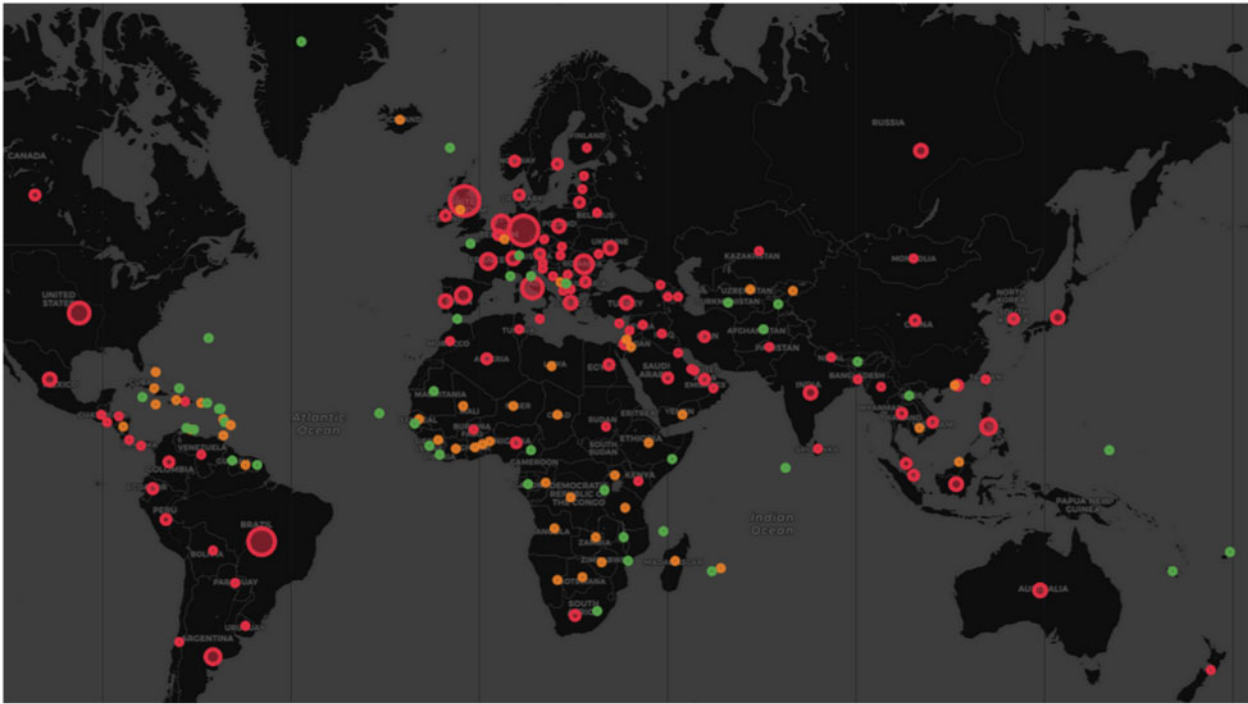
Figure 5 Connection patterns to ESC Congress 2020 on day 1 in the afternoon central European summer time.
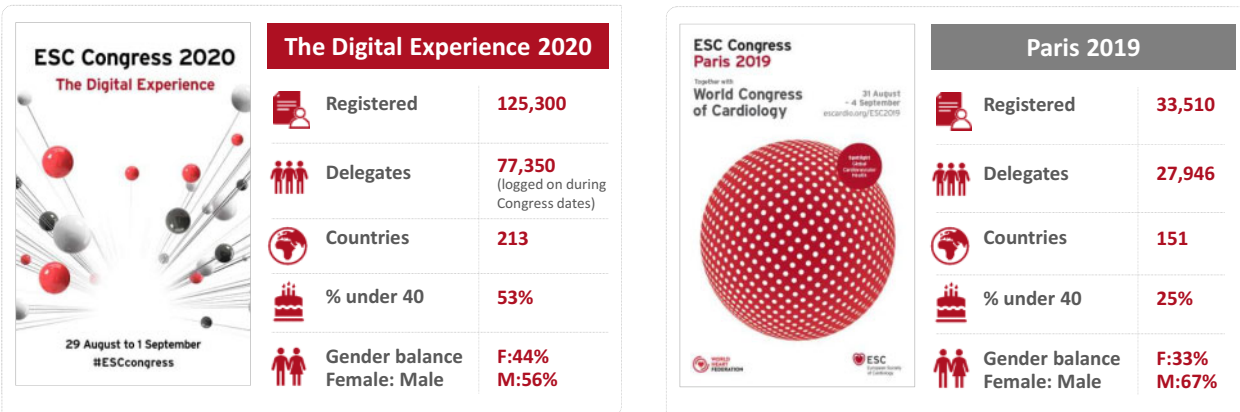

Figure 6 Key figures of the 2020 and 2019 editions of the ESC Congress. Adapted with permission from Roffi M *et al. Eur Heart J* 2021;42:2812-2813

Connection patterns

One of the main concerns was that participants would connect for very limited time. Indeed, it was a major challenge to have people connecting during four days (2 week days and 2 days on the weekend). In fact, during in-person meetings, attendees are largely 'protected' from private or hospital duties, while this is not the case

for digital meetings. The initial experience with smaller digital meetings taking place in the first half the 2021 were quite sobering it terms of connection time of the participants. And many of the actions we took (3D studios, live sessions, 'TV feel') we aimed at increasing the connection time. A total of 81 098 delegates logged in, 11% the day before the congress, 95% during the congress dates, and 28% from the end of the meeting until 30 September 2021. Among those

connected during the meeting, approximately 80% logged in during congress hours and 20% 'off hours'. On average, 37 963 delegates logged on to the congress platform each day. Users spent an average of 77 min using the platform during congress hours and 20 min using the platform 'out of hours'. More than half of the delegates (53%) logged in on more than 1 day. Based on previous data, these connection times are remarkable. The splitting of unique viewers according to the topic of the pre-recorded programme and day of the meeting is displayed in Supplementary material online, Figure S7.

Analytics and delegate's feedback

In order to have a proper assessment of the impact the meeting, data collection was considered a priority. Necessary tools and processes were put in place to collect data from three sources: registration data, to get insights into the user's profile; navigation data (100 million clicks, play, etc!) to address user's behaviour and survey data to analyse the feedback. The technically complex collection of navigation data was ensured by a company specialized in big data infrastructure using open source solutions. The company was already working with ESC to implement a big data cluster to support an ESC data lake; thus the system was enriched to collect all the events on the platform (real-time capture of all 'clicks' from users). The challenge was not only to collect millions of events, but also, to consolidate 'clicks' with external sources, in particular the geographic position associated with the IP addresses. The storage of all those events was a key component in the analytic system. Some dashboards were available during the congress to follow up participation and engagement, while the bulk of the data was made available to the ESC marketing and the scientific teams after the event. Navigation data showed 100 million clicks throughout the meeting and, among those, 261 172 h of video viewed, 14 527 clicks to zoom ePosters, and 13 445 clicks on promotional banners.

According to an ESC post-congress survey, filled partially and totally by 11 500 and 7600 participants, respectively, ESC Congress 2020 was the most successful edition ever. Compared with the 2019 edition in Paris, which was the highest rated in the history of the meeting, the proportion of responders who qualified the congress of 'great' increased from 83% to 89%, while the proportion evaluating it as 'poor' was reduced from 3% to 1%. Like previous in-person ESC Congresses, viewers indicated that Guidelines and Hot Line sessions were the key drivers for their attendance (Supplementary material online, Table S1). Interestingly, to the question on how they would attend the next edition of the meeting if it was hybrid, 61% of the responders favoured a digital connection while 39% opted for attending the event in-person.

Continuing medical education credits

ESC Congress 2020—The Digital Experience was accredited by the European Accreditation Council for Continuing Medical Education (EACCME®) for a maximum of 24 European continuing medical education (CME) credits (ECMEC®s). Delegates were granted one CME credit per full connection hour during the event (29 August—1 September 2020) and a maximum of 6 credits per day for the hours spent watching videos. Delegates needed to confirm their interest in receiving CME credits during the registration process. After the event, these delegates were requested to complete an EACCME evaluation form and could download their certificate including the CME credits from their MY ESC account.

Conclusion

ESC Congress 2020—The Digital Experience represented a great challenge both from a scientific/educational as well as from an IT/video production perspective but resulted in an undisputed success. The most evident fruits were an almost four-fold increase in the number of registrations, when compared with the 2019 record-breaking edition in Paris, and an increased representation of younger and female participants as well as of participants from low- and middle-income countries from the five continents. No major technical failures were encountered and the society acquired knowledge and skills on big data infrastructures and artificial intelligence algorithms. For the first time in history, attendees from all around the globe benefitted the same real-time access to the world's most popular cardiovascular conference. The only requirement were a connecting device and adequate internet connection. While ESC leadership eagerly await the opportunity to meet again in person to share the latest on cardiovascular practice and science, it not forget participants who were on board for the first time in 2020 and the ones who might never be able to attend an ESC Congress in person. Therefore, future editions of ESC Congress will have a digital component.

Supplementary material

Supplementary material is available at European Heart Journal – Digital Health online.

Conflict of interest: BC declared travel support for attending meetings in her role as ESC President-Elect, President & Past President; CG, NN, GD and IB are employees of the European Society of Cardiology.