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LEAPS

Integrating Multi-Disciplinary Expertise in a Learning and Adaptive European Pandemic Preparedness System

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Contents

Executive Summary

To better understand the role played by communication in pandemic preparedness and response, interviews with subject matter experts (SMEs) were conducted to assess the main communication challenges experienced between policymakers, healthcare professionals and academia during the COVID-19 pandemic. This purposely excludes the general public. The reasoning behind this exclusion is the need to scope the research and focus on understudied target audiences. As these emerged, opportunities were explored to identify ways forward to improve communication in the context of pandemics.

A central challenge appeared to be misunderstandings of the different worlds each stakeholder groups live in – the interface between policy making, evidence-based research and health professionals is complex. Not understanding what is a stake for each group promotes frustrations and unclear and even biased communication, which can be tackled by improving the understanding of the various roles and responsibilities, as well as offering spaces for dialogue to promote feedback, clarifications and adjustments.

An added burden is the challenge imposed by uncertainty and lack of access to data, especially in the early stages of pandemics. Change is required in the data infrastructure to offer real-time data that can be further analyzed as well as leveraging networks to share learnings as much as possible across institutions, countries and disciplines.

The digital world in which all stakeholders are embedded adds a layer of complexity through the challenge of misinformation, disinformation and fake news. Ensuring that research preserves its independence and quality even during times where information needs to be processed quickly, regulating the media for quality control and remaining reassuring and empathetic are key to dealing with this. However, much more research will be required to discuss the way forward with these issues.

Overall, it is crucial to embed lessons learned in a structural and sustainable way, so that knowledge is preserved from pandemic to pandemic and generation to generation. The COVID-19 pandemic highlighted key areas for improvement, but also clear capacities and strengths which can be preserved and maintained in the event of a future pandemic.

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Abbreviations

HCW	Healthcare workers
LEAPS	Integrating multi-disciplinary expertise in a learning and adaptive European pandemic preparedness system
WP	Work packages
EU	European Union
ATM	Access-to-Medicines
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
AMR	Antimicrobial Resistance
WHO	World Health Organization
HERA	Health Emergency Preparedness and Response Authority
SMEs	Subject Matter Experts

Introduction

1.1. Science Communication and Crisis Communication

In the context of the research projects, various results are produced. When these results are distributed, shared, and explained to an audience outside of the scientific community, this is referred to as science dissemination. There are diverse methods on how to disseminate, by whom using different directional flows, according to the strategy, and positioning. The goal of **science dissemination** is to make sure that the results are shared so that they can be reused by all (Van Even, 2023).

Science communication is broader than science dissemination as it refers to elements that go beyond sharing the results of the science, and also aim to strategically share methodology, processes, and people involved but also raise awareness, visibility, and understanding to not only reuse the information generated by science but also understand the pathways behind the production of results to ultimately improve scientific literacy and build trust in science. Indeed, its ultimate aim is to influence opinions and change behaviors (Van Even, 2023).

In times of crisis, science dissemination and communication become altered, as new elements shape the field such as the rise in propaganda and persuasion. This is reinforced by the current **digital landscape** with the diverse social media platforms accessible (Van Even, 2023).

1.2. Communication dynamics in the context of COVID-19

The SARS-CoV-2 pandemic emerged as a global crisis that highlighted challenges in communication but also its importance in shaping the response, as communication showed to **influence the adherence and acceptance** of public health and social measures put into place by governments. Indeed, communication is crucial in **influencing knowledge, practices, and behaviors** to reduce transmission and protect people from the disease (Kisa & Kisa, 2024; Onilov et al., 2024). During the COVID-19 pandemic, the goal of science communication was to **promote knowledge of COVID-19 transmission**, protective measures, and vaccines, and promote adherence to public health and social measures (Jacob, 2023.; Onilov et al., 2024). It aimed to develop strategies to persuade them into **change their beliefs and behaviors** to meet the public health goals of managing the pandemic by reducing risky behaviors, promoting protective behaviors, and building institutional trust (Davies, 2022; Ettinger et al., 2025; Jacob et al., 2023). Therefore, exploring the dynamics within science communication and the system in which it is embedded can further support the management of pandemics and inform future science communication approaches in the case of a future crisis (Kisa & Kisa, 2024).

The COVID-19 pandemic was embedded in a dominant use of social media highlighting a clear change in modern communication dynamics. As mentioned previously, **social media platforms** can be used as drivers of propaganda and persuasion as rapid communication vehicles. The SARS-COV2 pandemic highlighted great challenges related to **misinformation, disinformation, and rumors** through these social media platforms (Kisa & Kisa, 2024; Onilov et al., 2024). Indeed, the rise in new technologies and the importance of media in current societies adds a layer of complexity to sharing and understanding scientific information by allowing a flow of unverified shared information next to verified information (Van Even, 2023; World Health Organization, 2017). Essentially, the inability to monitor and evaluate these

communications allowed space for misinformation, disinformation, and rumors to spread and rise. Although these are highlighted areas of difficulties, social media has also been leveraged with positive communication impacts. This entices more research in how social media is used in risk communication and its diverse array of impacts.

The pandemic also showcased its **complexity** with science being entangled with societal concerns, international relations, and beyond. Alongside this complexity came a surge of information from different channels and various sources creating an information overload referred to as "**infodemic**" that made it challenging to fully grasp and control the flow of information at a sufficient speed (Onilov et al., 2024; Wald et al., 2022; World Health Organization, 2017). The time between evaluating the media, identifying incorrect information and debunking was too slow as it allowed ample time for it to spread in the meantime. Although control measures had been put into place by the EU, they were insufficient in dismantling this spread (Renda et al., 2023).

Trust in science was also widely reported as challenging although it differed between countries according to social and political perspectives and relationships between societies, governments and scientific institutions (Wald et al., 2022). When trust in governments was low, this led to high skepticism in communication due to concerns about political communications and leveraging the crisis as a tool for political influence (Mohamed Nour & Kisa, 2024). This relates to Van Even's notion of spreading propaganda through social media which brings up the theme of concerns over political parties taking advantage of crisis and **restricted freedom** to promote their own political agenda (Van Even, 2023). Indeed, this is related to the issue of persuasion, social control, and ensuring population compliance with public health measures (Mohamed Nour & Kisa, 2024). There is tension between using scientific communication to inform and to manipulate which appears as a threat to democracy, especially given the high power of knowledge institutions which become even more important during times of crisis (Davies, 2022).

Additionally, challenges were experienced in the **translation of science to policy-making** (Kisa & Kisa, 2024). When approaching decision-makers, scientists could expose data and share advice on the COVID-19 virus and its implications. However, this did not imply that scientists were making the decisions on the countermeasures. This caused a few tensions when having to clarify scientific information or clarify the reasoning behind countermeasures, as these were not only based on scientific advice but also influenced by other factors such as societal challenges (Hyland-Wood et al., 2021). Furthermore, the way policy translates science into public measures might not solely consider science but might weigh various priorities (Hyland-Wood et al., 2021; OECD, 2025). Overall, there was a gap between evidence-based research advice and policy translation that may or may not consider the evidence.

This deliverable focuses on communication between policymakers/health authorities, academia, and healthcare professionals. These stakeholders each hold different but crucial roles during pandemics. **Policymakers** rely on scientific evidence to formulate public health policies and guidelines. They require access to the latest research findings and expert recommendations to make informed decisions. **Scientists** can generate evidence and insights that inform policy.

Their role involves conducting research, analysing data, and providing expert opinions on various aspects of the pandemic. **Healthcare workers** implement policies based on the guidelines provided. They are on the front lines, translating policies into practice and providing direct care to affected individuals including providing medical information. This research aims to better understand the multi-dimensional flows of information between these nexuses of stakeholders (El-Jardali et al., 2020; Goldstein et al., 2020; Naughton et al., 2024).

Overall science communication is reported to highly influence people's thoughts and behaviors and the SARS-COV2 pandemic highlighted specific communication needs in times of crisis which can be referred to as *science crisis communication* (Mohamed Nour & Kisa, 2024). This review aims to explore the main emerging variables to consider when planning science communication during a crisis to further improve and address limitations. However, it is important to keep in mind that although science communication can shape risk perceptions by **contributing to reducing risky behaviors,** communication is only one of the multiple factors involved in reinforcing pandemic management among many others in the whole system (Onilov et al., 2024).

Acknowledging the challenges mentioned, specific strategies have been recommended throughout the literature to influence public understanding and compliance with measures in order to improve pandemic management (Kisa & Kisa, 2024; Mohamed Nour & Kisa, 2024).

1.3. General Recommended Strategies

1.3.1. Trust

To allow science to guide behaviors, it requires that science is viewed as accepted, useful, but above all, trustworthy. Therefore, ensuring that stakeholders trust the science generated and those who conduct it is essential (Van Even, 2023). Regardless of the ultimate decisions made, researchers hold the responsibility to communicate advice grounded in evidence (Onilov et al., 2024).

A pathway to addressing this trust issue can be through tackling trust issues related to **social media diffusion of content**, and this must be further researched (Mohamed Nour & Kisa, 2024). Clarity and up-to-date information are needed, as well as control over the different versions of information. As new evidence is generated, social media must be **continuously updated,** with errors being communicated in a timely manner, as **delaying communication can result in rumors** (George et al., 2023; World Health Organization, 2017). Fact-checking and identifying logical fallacies are essential in evaluating the content circulating (Hyland-Wood et al., 2021; Jacob et al., 2023). Additionally, social media must not remain the sole reference for information, and promoting communication through a diverse network of channels combining traditional and modern channels can ensure that a larger audience is reached in various ways. The **information flow** must also be well managed through strong coordination (Jacob et al., 2023; Mohamed Nour & Kisa, 2024).

1.3.2. Science translation into policymaking – evidence, dialogue, and transparency

Another avenue is to distinguish the limits of science and the role played by the **political environment in guiding decision-making** on countermeasures. The translation from scientific information to decisions must follow a clear communication strategy to distinguish science from policy-making. This would require specific strategic tools such as flexible emergency plans for agile governments as well as advice on mechanisms for **providing scientific advice** (Kisa & Kisa, 2024b; OECD, 2023). Having scientists explain decisions they are not responsible for should be handled carefully to differentiate science from policy-making (Hyland-Wood et al., 2021; OECD, 2023). Nour et *al*'s article further investigated this issue of how leaders can continue to make science-based policy-making while remaining engaged with society to keep all perspectives into account (Mohamed Nour & Kisa, 2024). Indeed, **preserving multiple pathways of information flow** amplifying unheard voices, and moving away from one-way communication to **two-way communication** was encouraged as a way to provide other forms of data than purely biological, epidemiological, and statistical infectious-disease-related data. This implies space for **frequent dialogues** as repetition is key, especially on long crises such as the COVID-19 pandemic (Davies, 2022; Ettinger et al., 2025; World Health Organization, 2020). Although this approach may be more time-consuming, it ensures that messages are understood and allows a wider range of data to be shared which can be crucial in addressing more socioeconomic challenges experienced by communities (Mohamed Nour & Kisa, 2024). Ultimately, it also allows us to engage in the crisis with humility, exploring the landscape of opinions as widely as possible (Davies, 2022).

Also, ensuring that policy-making is **evidence-based** and communicating can help understand the supportive data and evidence behind decisions (Kisa & Kisa, 2024; Mohamed Nour & Kisa, 2024; Onilov et al., 2024). Reaching out to scientists, researchers, and healthcare providers was essential to science communication especially related to vulnerable groups and providing information on the continuity of care. **Leveraging already existing networks** can also further support targeted communication (Hyland-Wood et al., 2021; OECD, 2023). This requires transparency in data, including **transparency** on economic costs, public beliefs, and reasons behind decisions (Ettinger et al., 2025; Hyland-Wood et al., 2021). Indeed, transparency on how advice is provided and about the decision-making process following the reception of advice is recommended to increase trust related to science translation to policy-making (OECD, 2023). Without this fundamental trust in science, communication is bound to fall short (Van Even, 2023).

1.3.3. Networks and Relationships

Ultimately, building trust is embedded in **building, engaging, and maintaining trustworthy relationships** in the long term. By building coalitions or groups that connect not only with the aim to influence one another but to discuss, trust can be fostered. When one knows one another, it enables an easier response to pandemics by knowing who, where, and how to contact the stakeholders you need (Ettinger et al., 2025; World Health Organization, 2020). When maintaining these relationships, other benefits are added such as being able to collaboratively

identify priorities and establish a common vision. **Keeping track of barriers to collaboration** also helps tackle these barriers once the crisis is over. Overall, building these relationships in peacetime is essential to crisis response in order to rely on networks and knowledge of one another (World Health Organization, 2020).

Because this deliverable specifically focuses on the nexus of communication between policy-makers, researchers, and health professionals, more specific recommendations related to these stakeholders are added below.

1.4. Specific Recommendations Strategies

1.4.1. From science to policy

Specifically when reaching out to policy-makers, first **streamlining scientific advice** from skilled personnel, and experts and gathering already existing data can condense information into more digestible formats as well as reduce potential conflicts in advice (Renda et al., 2023; World Health Organization, 2017). Disagreements when sharing messages also came from unclear roles and responsibilities of advisory boards but also from other institutions such as ECDC, ad-hoc advisors, and already established networks of scientists. **Clarifying their functions, mandates, and scope** would enhance the structure and enable planning in case of diverging opinions (OECD, 2023; Renda et al., 2023). Additionally, more **transparency** behind the creation of the advisory boards would enhance trust (Wald et al., 2022).

1.4.2. Advisory boards

Further related to these advisory boards, as pandemics evolve, **needs evolve** as well. The members of the advisory boards show growth and adapt to the situation as well as larger expertise from solely including epidemiologists to also including social sciences (OECD, 2023). Indeed, a multidisciplinary team that evolves over time is required to effectively design policies (Renda et al., 2023).

1.4.3. Communicate uncertainty

Furthermore, the concept of evolving and adapting is the requirement to remain **open to uncertainty** (Hyland-Wood et al., 2021; Wald et al., 2022). This is part of an important aspect of science communication referred to as credibility which is highly related to trust. Credibility is related to competence, technical expertise, dependability and reliability, commitment and care(World Health Organization, 2017). Acknowledging uncertainty whether it is spokespeople, policy-makers, scientists or healthcare professionals establishes the limits of the known and helps build trust, especially since trust related to scientific misconduct in previous occurrences has broken down this trust in science(Van Even, 2023). Credibility is also why healthcare professionals are often more trusted than policymakers (Jacob et al., 2023). It is even recommended that they serve as messengers or intermediaries (World Health Organization, 2020).

Evidence-based communication carries the risk of being complicated to understand. When addressing policymakers, the evidence must be timely, concise, and accessible. This implies

working on **the "how" behind communication** which involves finding ways to offer information that is comprehensible to the audience(World Health Organization, 2020).

1.4.4. Understanding policy landscape

First, take the time to **understand your audience**. This enables a more targeted communication which has been recommended through the literature as a way to make the research more relatable and relevant. By customizing the way you communicate to the targeted stakeholder, especially in relation to values, your research becomes more attractive (Ettinger et al., 2025; World Health Organization, 2017, 2020). This implies understanding the practical realities of policy-makers, knowing more about the international/national/regional laws that influence decision-making and shaping policy development to further identify opportunities for change in public health and social benefits (World Health Organization, 2020). Adapting to different political parties in the field of science communication requires further research, especially as there are debates about preserving democratic and free science (Davies, 2022; Mohamed Nour & Kisa, 2024).

1.4.5. Clear and simple communication

The **style** of the communication briefs must go beyond text and data, but also include narratives, and visuals (graphs, print materials, YouTube videos, infographics and pictures) putting the research into perspective by adding the frame, the geographical scale and the long-term vision. These create a more human dimension to scientific communication which promotes overall understanding, provided other elements such as terminology, simple language, translation and clarity are also accessible (Ettinger et al., 2025; Kisa & Kisa, 2024; Mohamed Nour & Kisa, 2024; World Health Organization, 2017). It could be interesting to explore social media as a channel to promote such clear and simple communication while considering challenges reported previously.

Indeed, **health literacy** must be kept in mind as graphs can be misunderstood, and quantitative data can be confusing as numbers do not appeal to all compared to texts and words (Hyland-Wood et al., 2021; Naughton et al., 2024; Santana et al., 2023). In order to address the tension between following public health measures and individual freedoms, leveraging science communication not as a tool for persuasion the way it is used in marketing, but as a way to **enhance critical thinking**, and promote individual decision-making (Davies, 2022; Van Even, 2023).

1.4.6. Empowerment

Empowering to act is key as knowledge does not evidently transfer to behaviors (Hyland-Wood et al., 2021). This can be achieved by **making advice actionable**, and clearly stating what should or should not be encouraged over specific time periods and providing skills to enhance policymakers' confidence (Hyland-Wood et al., 2021; World Health Organization, 2017). Additionally, communicating beyond the risks is essential to assess risk perceptions, and reactions to risk, support the promotion of risk understanding, and also address concerns about risk. This requires the **expression of compassion and empathy** to reduce anxiety levels and to reassure by offering a sense of control (Hyland-Wood et al., 2021; Mohamed Nour & Kisa,

2024). Finally, focusing on the impact of actions and milestones by showing that efforts have rewards helps demonstrate how behaviors made a difference which serves as encouragement (World Health Organization, 2017).

Methods

The aim of this deliverable is to provide a report on the communication dynamics between health authorities, healthcare professionals, and academics that occurred during the SARS-COV2 pandemic in order to define the main communication challenges to be further addressed in the course of this work package. Indeed, the report ends by offering the content to prioritize when creating pandemic training materials. The challenges and information gaps identified can then inform the creation of a MOOC for healthcare professionals and dashboard for policymakers as well as materials to promote understanding which can be disseminated through the project's networks. These materials will be co-create with communication professionals.

To first have an overview of the literature landscape, a concise review of the literature aimed to investigate science dissemination and communication, more specifically in times of the COVID-19 pandemic crisis. Interviews were conducted to investigate the dynamics between the three selected stakeholder groups, changes in communication between normal and crisis times, topics that were communicated, where and how to further understand the strategies that were used, and assess how these impacted behavior and viral spread. Overall, it implies investigating **knowledge gaps**, different interpretations, trust, misinformation, **and related behaviors** to better inform and support **improved decision-making for pandemic preparedness and response**. The interviews spanned between about 45-120 minutes, online or in-person according to preferences.

The interviewees were selected according to their implications in crisis communication during the covid-19 pandemic, and their field of study aiming to represent all the methods and scientific knowledge promoted by each work package. Each work package lead provided 2-3 recommendations for candidates aiming to balance field specialty as well as country representativity. According to their availability and response, a total of 18 interviews were conducted following a semi-structured interview style from institutes affiliated to Belgium, France, Greece, and Switzerland. Through snowballing, additional stakeholders were interviewed according to the recommendations of interviewees.

A thematic analysis followed the interviews structured into main challenges, actions recommended and possible training avenues. These are further put into perspective into the discussion section where quotes are leveraged to highlight certain aspects of the results.

Overall, these qualitative results provide valuable learnings on the role of communication in the spread of disease and health impacts. It provides a way forward on how to better leverage communication in times of crisis for improved pandemic preparedness and response.

Limitations: Some difficulties were experienced when reaching out to interview candidates when they had no personal established connections with either the primary researcher of this report or a work package lead, leading to a bias towards having more interviewees coming from

Belgium. This showcases **the value of personal relationships** in accessing valuable qualitative insights for research. It is to note, however, that five work packages over nine are established in Belgium and/or related to a Belgian institution, respectively, WP3 (partly), WP6, WP7, WP8, and WP9.

Results

Challenges

1. Complexity of crisis management

1.1. Translation of scientific expert advice to public health and social measures and regulations

Most interviews report having an advisory group made up of scientists that advise the health authorities and policymakers. These advisory groups were often made up of epidemiologists, virologists, infectious disease specialists, and public health professionals. In crisis, the need for advice increased, and policymakers reached out for scientific input to guide their decision-making. However, the complexity and subjectivity of crisis management was unexpected. There was confusion around **understanding the reasoning** behind the decisions that were made.

"You have to understand that as a policymaker it's a very different environment than as an advisor because of course a measure may be, let's say, purely from a scientific perspective, the most natural thing to do. But if it's very hard to sell that to the general public, the policymaker may not follow."

"The way the people react to facts is not politically naive, because these are politicians (...) If you have a politician in front of you which is liberal, he will go in that direction. If you have a communist, it's going to be totally different with the same level of information. You can be totally neutral, and I think that is necessary. That doesn't mean that what comes next and the interactions following (will be neutral)."

The results showcase how some advice could lead to a wide array of decisions, which could vary according to the context and the various variables influencing it. Indeed, this can explain cross-country differences. It emerged that **although scientific advice is objective, decision-making is subjective** as it is influenced by the political party's viewpoints, agenda, and intentions. Indeed, crisis management cannot be purely scientific as it concerns wider social, economic, and cultural factors within a society. This would not only raise confusion but also frustrations over **decisions that were misunderstood**, absurd, inefficient, or deemed unfair.

"At times it's difficult there because you know that this is not the best approach to be taken. So emotionally, that's very difficult because you really worked hard on getting a balanced design out, I mean, a balanced advice out. But then, rationally, you also say like, 'OK, I played my role, and I've really lived up to that. I give advice and I'm not the one taking decisions."

"The question is 'why is not happening'? And I think that when you ask why is not happening, it's because of interest and power and other another dynamics."

This misunderstanding could cause scientists to be prescriptive in their advice instead of offering recommendations which led to frustrations between both groups.

"They (policymakers) *reminded us of our rule that we were advisors, not decision-makers. (...) They would explain to us, you know, that this is what they're dealing with - the pressures they're dealing with. If we could perhaps maybe tone down the prescriptions a little bit and just, you know, give options maybe. I think that most of the challenges with the communication came from when scientist kind of forgot their place, right? I think they didn't understand the policy environment very well and what goes into policymaking. And it's not just evidence based decisions based on science, it's evidence-based and experience based decisions based on a lot of factors, right?"*

Indeed, the previous quote reflects the need to consider policymakers' challenges in regard to **public acceptance** of the decisions they would take. Measures would be less likely to be accepted if the infringement of freedoms were too high. This is especially relevant as interviews report that public acceptance might become an even bigger challenge in the event of a future pandemic. Overall, policymakers are reported to live in a different world with a specific culture and needs.

"You have to understand that as a policymaker it's a very different environment than as an advisor because of course a measure may be, let's say, purely from a scientific perspective, the most natural thing to do. But if it's very hard to sell that to the general public, the policymaker may not follow."

"I think this is something to be, this is something expected, you know. Governments and public systems work in a particular way. You know that is not always - how can I say - we cannot really understand. It can be less efficient sometimes or you have to go through many steps in order to get the thing done. You know, you have to go through many desks (...) although the ears were always open there were always arguments coming back to us 'oh we cannot go out and say that' or yeah, to the public."

1.2. Prioritization and tradeoffs

Decision-making is also influenced by the **stakeholder landscape**; research institutions being only one among many actors aiming to influence policymaking. Each stakeholder will have their own agenda and will advocate for their interests. Policymakers are exposed to all these inputs. Additionally, different stakeholders may have different stakes which implies that one scientific advice might suit one stakeholder but not the other. These **differences in implications** also complexified the requirements to meet each stakeholder, which further complexified decision-making.

"But we just have to understand in a system that we live in that different political parties have different opinions."

Prioritization became even more difficult when access to information itself was challenging.

"The prioritization was quite a big issue for us because at that time you remember very, very well. There wasn't much scientific information about the disease and about the vaccines and about what have happened. So prioritization for us was quite, quite a story. (...) the whole prioritization for vaccination was based on three things. First of all, scientific facts. (...) The second factor was moral issues. (...) So our basic principles, moral principles, had to do with producing the best benefit for the patient, not causing harm. Principle of being all equal in our potential to obtain the vaccine, and that should be done according to justice. And then there were also issues like being fraternal to each other and being responsible for as much good to the society (...)And the 3rd principle, it had to be all very clear to the public. The public had the right to know, so we had to be very clear to them"

While balancing their own agenda as well as the agenda of the stakeholders around them, policymakers must prioritize. According to the priorities made, future decisions will also be affected. This requires high levels of responsibility from policymakers, but was often misunderstood by scientists and healthcare professionals when the **justification behind the measures** taken seemed unreasonable to them. This misunderstanding was also linked to mistrust. A researcher and advisor report the following:

"If you then get an advice, I think you have the right to say 'OK, we follow the advice or we still decide something else' if you have other factors that play a role, but when you do not follow the advice there needs to be a sound explanation of why you don't follow, and even if that explanation is 'that's not a popular decision'. Yeah. OK. Then that's their responsibility. But it's not ours. We only give an advice in that sense. There's not much responsibility coming with an advice as such because they can still decide 'yes or no'."

This is where pandemic response modeling sometimes proved to be challenging as it might not reflect the priorities of the policymakers. Although models were reported to be appreciated by policymakers by offering different scenarios, they also **felt prescriptive** at times.

"I think they (policymakers) *were always appreciative but with modeling, I think so many countries learned the hard way that politicians are not well schooled, well-educated into what modeling does, right. And so they saw it initially as very prescriptive. They didn't understand assumptions. They also thought it was very easy and not time-consuming at all to do."*

1.3. Unclear roles and responsibilities

Many institutions had identical mandates or would share responsibility. For example, laboratories in Belgium often shared assigned roles as with Sciensano, the national public health organization. The scope of institutions was left unclear leading to confusion, frustrations, inefficiencies and sometimes loss of information.

"Who does what in terms of topics? What kind of advice can you provide and what is the time frame? 48 hours, six months...?"

Additionally, **information flows** damaged the clarity of communication since the mandates did not justify where and to whom the information must go to nor how it should be provided. This was particularly highlighted in an interview mentioning other pathogens, such as Avian Influenza, which would involve more than only the Human Health Ministry.

"It was a mess in terms of communication. Why? Because initially, it was just a veterinary problem. The chicken farms. (...) But then from the moment the cats were positive, you enter already in a different scenario in terms of communication. And then also the human cases. So the question was who was supposed to communicate about what and when? "

"And I think this new challenge with this One Health zoonotic potential outbreaks that's a bigger challenge than well, not than COVID, but in terms of governance, in terms of communication information, it's complex."

"For avian flu, you have to add this one health component with the animal surveillance and that's where the difficulty is because we all talk about one health but we know how difficult it is to combine two surveillance systems, so one of the animals and the one of humans."

Indeed, zoonotic diseases are foreseen to involve even more stakeholders and given the fact that there is no hierarchy between them, the communication of information will be even more challenging.

As laws and regulations change during crisis times, so do roles and responsibilities. This caused friction when roles were not respected, especially in emergency times hold different needs than in normal times and may include changes in stakeholders and changes in responsibilities.

"We (scientists and healthcare professionals) *would always have good discussions and I don't ever recall any heated discussions that we couldn't resolve. But I think it was when people kind of stepped out of their expertise and didn't listen, but they really wanted to impose. "*

In the end, it was unclear who would be responsible for implementing the advice provided.

"The idea was that we would have the package ready and we can just send it out to everybody. But as I was mentioning, sometimes there is a region saying 'no, we don't agree with this' or a minister saying 'no, we don't agree' or a cabinet… And so you're back to, you know, back to start actually "

1.4. The role of scientists in justifying decision-making

Lack of clarity regarding mandates, information flows, and uptake of advice sometimes led scientists to take on a decision-making role that was not theirs to take on. Indeed, there appeared to be a blend between the advisory role and the decision-making role, which sometimes caused frictions between the two stakeholder groups.

"The expert is a man who has to advise the policymakers and help the policymakers to come up with a plan, a plan work and a plan that will be effective."

Additionally, the previous point of seemingly unjustified decisions made researchers uncomfortable, as they often had to report on the reasoning behind decisions.

Indeed, scientists and healthcare professionals were at times used as public representatives in the media to explain the measures that were decided upon. However, scientists' role was limited to advising and not making decisions, which often made it difficult for these media representatives to justify the decisions, especially when they diverged or did not fully adhere to the advice given.

"After a while, it was more (...) political (questions) than actually questions that, we, as a reference expertise center, could answer."

"Most of those people were just scientists, researchers and academics that had nothing to do with policy-making, etcetera. So they were understanding the virus, they were understanding the dispersal patterns. They were understanding the relative risks, etcetera. But they had nothing to do with applying these decisions and measurements."

Additionally, there were challenges in terms of preserving scientific neutrality vis-à-vis the government when explaining the measures applied.

"Some people felt like we were too close to the government because we're advising them to be the right people to provide these explanations (to the media), *but at the same time, I mean, I think for many people who were eager of having information, they considered that this was a reliable source of information compared to all of the disinformation that you could find in social networks and elsewhere."*

However, it remains crucial to have these decisions explained, especially if policymakers make decisions not only based on evidence. Providing an explanation is essential to public adherence.

"I don't think, I know, one of the challenges we had in some cases during the pandemic was that our government told people what to do but not why. So I think the 'why' needs to be there and it was often missing. (...) You know, it's like: 'You have to do this' instead of really explaining and inviting and empathizing with what people are going through, I think that's something New Zealand did really well."

1.5. Interpretation

Results were often misinterpreted, leading to regulations that did not reflect the scientific advice provided. At times, advice led to oversimplified measures or overcorrections which raised mistrust.

"You say: this needs to be done and this and this and this. And when we publish, when the advice was sent to the policymakers, to the politicians, and so on, you felt that they were kind of shopping. This was a shopping list. And of course, that's not the idea. You can't have a shopping list. (...) The lesson learned there is one thing is that we gave one advice with a little room for selection, let's say. So what I would ideally hope for, in the next time around let's say, is that, and certainly on terms of pandemic preparedness, that you can actually propose different options and then they can depending on their color, their party and so on, they can still actually maneuver around and discuss amongst each other."

"There's a huge difference between what we perceive to have communicated and what we have communicated. (...) We think that we have understood and we often over estimate communication. (...) Most of the time people do not understand. It's not about bad practice, good practice."

Interpretation challenges could also occur between policymakers to healthcare professionals. At times, hospitals would interpret regulations differently meaning policies were implemented differently across hospitals.

"So hospitals interpreted themselves or individuals interpreted themselves according to their ideology."

Finally, the media was a common carrier of misinterpretations. This will be further discussed later in the results related to misinformation.

2. Balancing complexity with clarity

Preserving nuance while remaining clear was often reported as a challenge, as scientists struggled with clarity due to the high levels of uncertainty while policymakers required clear messages for decision-making. The challenge revolved around answering questions regarding very abstract concepts in an understandable way without compromising scientific validity.

"There is signal and there is noise. You cannot avoid the noise. You try to capture the signal as good as possible and you quantify the noise, the uncertainty. It's a very difficult message for politicians and for the general public. Not so much for scientists who are in a field that is also very much written by variability."

It was reported that policymakers would have selective use of results engaging in **cherry-picking** behaviors according to their political agenda. By not using the full data and forecasts, they would **lose the nuance** of the scientist's advice, misinterpret results, and share false information that did not reflect the scientist's analysis. Indeed, small changes or reductions can alter the meaning and scientific value of advice.

"The message they want me to bring is not a message I can bring."

"When these ad hoc meetings would arise, then there was a voting mechanism to vote for what that the advice would be which I think is kind of ridiculous because if there is uncertainty in terms of votes, you're right on the uncertainty. And so tell that to policymakers so that they know that there is no consensus about this."

This challenge was especially reflected concerning vaccines when needing to report the risks as transparently as possible while remaining positive about the vaccine's efficacy and safety.

"That was also quite interesting because you know, when you're when you're going to receive a vaccine, you don't want to sign two or three or four forms saying, you know, talking to you about all sorts of things that you don't really want to think about"

3. Evidence-based decision-making

3.1. Invisibility of University Research

Universities **competing with other research** such as privately funded research and government controlled research came up often in the interviews:

"You have researchers from research institutions who can do this research but what we see (is) that a lot of research is done by other people than researchers from research institutions like universities or university colleges because the consultancy groups can do it very fast and very narrow."

It was reported to be difficult for researchers to reach out to policy-makers and vis versa to inform and influence policy-making. Policy-makers would **remain unaware** of the research conducted by research institutes. An interview reported that researchers did not believe they had the competencies to communicate their research:

"For example, if you have a website (...) and then you think 'OK everything is done now I move over to the next project' but policymakers are not going to your website because they're not triggered to go to your website."

This problem has been reported by a few interviewees to be caused by the academic **business model** for research where researchers are incentivized to publish a high quantity of articles. Their duty of service to society remains neglected due to lack of incentives. Researchers are limited in their time, but the results argue that if the business model were to promote quality over quantity as well as dissemination and communication of results, academic research would become more visible.

"There is a base in science that can say like 'this is garbage' because it's like wrong scientific methods really. The partisan choice of data and so on that can be discredited in no seconds. And the fact that these articles can be published, it's really worrying."

This lack of visibility is reinforced by the difficulties in reaching out, especially due to the high prevalence of indirect and formal communication pathways such as reports.

Overall, the lack of evidence in decision-making was a highly reported challenge. It made HCW and policymakers blind in guiding decisions when resources were not fully available. This sometimes led to inadequate policies that did not meet the needs or realities.

"We had to take the responsibility for decisions that were not compliant with the policy in order to you know, provide the care for the patients that needed it."

3.2. Garbage research

Many interviews reported challenges around infodemics but challenges in regard to **bad quality** research and research influenced by political stakes were also reported. In this context, safeguarding research is essential by upholding scientific methods, and research values.

"I don't believe in the research overload, no. It's I think the problem now we have a significant problem of garbage research now (...) Misinformation, it's also the result of the system that was created for research. So research has been linked too much to this economic model of basically publishing articles and a system of rewards as well related to these to these economic incentives, related to articles. And so I think that if you structure that, if you sell research in this way, this is what you get."

This is especially accentuated during crisis time when a lot of data is produced quickly and must be evaluated as quickly.

"At that time we would get like 10s of publications per week that were coming out and from all over the world and we really needed to go through that and evaluate them and see whether they stand or not and you know, see if they're good publications or not."

3.3. Missing and Untimely Data

In the crisis time, instead of having policymakers ask researchers for specific information, the communication pathway appeared to be initially flipped with researchers informing policymakers with content to help organize and prioritize according to the threat level.

The **lack of real-time** data made it especially challenging for communication because it entailed excessive communication multiple times a day. The report received was unstructured, and the it was **unclear** to whom to send the update report. For example, although regular reporting was necessary, it caused challenges in Belgium when this could not be done in a uniform manner by all labs across the country.

"If we don't have data, we're out of a job or we can't play our role. That's clear. So the data is crucial. Without the data, there's no need to have a conversation either."

The amount of communication needed was also reported as a burden in Greece.

"There were many arguments and strong arguments, and you know, scientists and medical doctors being also very aware that they should produce a benefit to the vaccine and not harm."

Furthermore, when policymakers implemented strategies that were not feasible for laboratories, it was a **challenge to report feedback** or practical matters that were left unconsidered. Finally, **the absence of real-time data fueled uncertainty** by working without evidence and not allowing anticipation of events.

Frustrations were reported when data from health agencies could not be accessed by researchers and other scientists. Even when these were available, they took so long to be published on their website, that the data quickly became too old. Although interviews recognized that the health agencies had different ways of operating and required rigorous data cleaning and high quality to avoid data misuse, this remained challenging as emergencies require quick access to ongoing data.

"They claim to be very open, but in fact they are not. And I understand why. They can't just share data publicly so easily. So I mean you have to find a good a good balance."

Additionally, there appeared reluctance to share data due to health agencies being protective of the data they so carefully prepared and reported jealousy towards researchers that had more freedom to 'play' with the data.

"They (health agencies*) know that if they produce data which are shown to be wrong later on, it will ruin the reputation of the agency so they are incredibly strict in their communication about data. And the world of the researchers we try to be very reactive to go fast. We don't*

have all the burden, you know, of the data collection, cleaning and everything. So for the health agency, it's a bit frustrating to see those guys who have plenty of time to make use of the data that they as health agencies have painfully produced (…) to have those outsiders coming and say: 'oh, you have nice data, I want to use them and I want to do my modeling'. It's very frustrating for the agency. "

4. Infodemics and Fake News

Mass media, information fragmentation, misinformation, and propaganda all contribute to raising confusion and fuel negative emotional responses.

"It's a whole ecosystem that has become very powerful."

This was reported to **erode trust in the government** and raise suspicions, especially as legitimacy was often questioned.

"Unknown resources from the Internet that were advertising these decisions and these measures as political, let's say, efforts to suppress the people opinion and voice and things like that there was like a restriction of freedom."

However, this is a relatively new issue in pandemics and it moved the issue to another dimension when involving HCW and having false experts produce false data to enhance "good tv" and stimulate debates all the more fueling mistrust.

"You cannot make the assumption that health professionals and policymakers are totally resistant to misinformation."

"They (HCW) have to be punished if they behave in a such a dangerous way because it's a dangerous way of spreading fake news and misleading people. As a health care professional your opinion has another, you know impact and the downsides can be really severe."

Additionally, the media fueled the mis and disinformation in order to create "good TV" and enhance debates by leveraging false experts.

"These are fake news. Information that travels across the Internet that is not confirmed, is not valid, can affect masses of people that are not able to discriminate and understand what is true and what's not. What's false and fake. So I think that the control of this information, although very, very difficult, is a crucial step. Basically, the control of fake news."

5. Communication with Healthcare workers

5.1. Protocols and plans were inadequately shared

When governments made changes in protocols, most of the time HCW were not made aware of these. HCW, who are mostly used to having changes in guidelines every 4 years, were sometimes receiving weekly changes in guidelines. The change was too fast and HCW did not

follow the pace. It became difficult for HCW to understand the value of all these changes in recommendations.

"I think that if you have a plan, but you never inform people, then the plan doesn't exist."

5.2. Translation and relevance of scientific advice for HCW

Similarly, as with policymakers, the translation of scientific advice to HCW needed to be translated into actionable advice that was relevant to the stakeholders. For example, the **implications of test results** on patient management.

"That is always difficult, even in a situation that is not a pandemic because it's not always that you speak the same language with a doctor."

This was further challenged by the **lack of harmonization in testing** where different assays would result in different numerical values that were not comparable. It was unclear for HCW how they should operate as it was challenging to understand the implications of a positive test on patient and hospital management.

"They were apparently a number of documents that existed, but they were never opened (...) Sometimes people don't even read the one of last week and they receive a new recommendation..."

"I think that if you have a plan, but you never inform people, then the plan doesn't exist."

These challenges highlighted the lack of a communication platform that regrouped all HCW specialists and the laboratories for decision-making purposes.

"That was probably the most useful, but also most difficult part of the communication. Really communication between peers. And a lot of experts never did that. Because it's much easier to be an expert on television than an expert in front of your peers."

6. Emotional Reactions

The crisis was high in emotions bringing fear, panic, and adherence fatigue which led to inadequate behaviors such as non-adherence to measures, over-presentation, or absenteeism at the workplace which was especially concerning when these behaviors came from healthcare workers.

"And the clumsiness in communication is an act of psychosocial stress (...) stress puts an extra burden on our cognition (...) we're stressed and we're tired and we fall back on cognitive shortcuts, and we start stereotyping. "

"There was also the police, the army, firefighters, everything that had to do with, you know, (...) almost war. And it was kind of like a war situation."

Many elements could fuel these emotions, but some specific aspects came up through the interviews such as:

- Frustrations related to misunderstandings. Many misunderstandings revolved around knowing about "the end of the pandemic", knowing when everything would end, the

duration of such living conditions, and such. These feelings were reinforced when bad news followed good news. Indeed, there was also a **misconception** that once people received the vaccine, the pandemic would be done. When it showed that this was not the case, it gave rise to elevated vaccine hesitancy. Overall, insufficient knowledge of the range of a countermeasure's ability caused misconceptions.

"Vaccination worldwide has saved millions of lives in the last 10s of years, but we tend to forget that. After the COVID vaccination, I think that people, instead of building their confidence on vaccines, I think the confidence of vaccines just came down with people. People don't want to hear about vaccination. (...) Although the COVID vaccines were very, very successful in preventing serious disease and death. I am completely sure that. If it hadn't been for the mRNA vaccines, we would have many more millions of deaths around the world. However, they didn't stop the disease. (...) So you could get vaccinated, but you could still carry the disease even if you were protected against serious disease and serious and death."

- Uncertainty and unanswered questions. The lack of real-time data contributed to this issue.

"I think that I think the bottom down conclusion for me would be that people need information and it's very difficult under these pressed conditions of a pandemic."

"People who are in a state of crisis be the micro crisis or major crisis are not rational. You have seen it in COVID…"

- Fear related to doubts of the neutrality of scientific advice.

"People thought that, you know, these scientists were chosen by the government because they were affiliated with the government (...) it has to be clear that these are scientists and these are independent scientists that are not affiliated with the government."
"By December, the head of the Public health group had to resign (...) from the task force in general because they held another mandate at a Swiss federal institution and there was, from the public's perspective, there could be some conflicts of interest."

- High levels of responsibility.
  "There were many arguments and strong arguments, and you know, scientists and medical doctors being also very aware that they should produce a benefit to the vaccine and not harm."

These emotional challenges often appear related to exceeded expectations. The misunderstandings around the feasibility of what could be done left people frustrated and this damaged the trust.

"There was one big mistake in Greece that happened on a governmental basis. The whole idea, the whole project of vaccination in Greece was named 'Eleftheria-Freedom'. And that was a mistake. Because the first message that the government wanted to give to people was: 'Do you want to be free to go around? Vaccinate yourself. Do you want to be able to go to the theatre again? Vaccinate yourself. Do you want to go on a travel? Vaccinate yourself.' Well, that would have been a very, very nice idea had the vaccine been able to cut down on the disease, not just protect against death. But when people realize that they can still contract the disease, even if they had been three or four times vaccinated. Then they lost their confidence to the message 'Freedom-Eleftheria'."

"For the side of the doctors sometimes they might ask things that are not so ... they're not possible to be performed. So there you have also to explain to them what is feasible and what is not and for the timelines as well - that is an another problem - the molecular methods are not rapid tests and they expected to have the same output of time as they had for rapid test, which was also not possible."

However, although emotional responses are high, waiting to act has dire consequences in crises like pandemics that require quick action.

7. Sustainability of pandemic preparedness and response

The responses during the pandemic were very dependent on individuals and their networks with other individuals thereby challenging the sustainability of response for future pandemics. When relying on individuals, there is a risk of "memory loss" as individuals grow older or pass away meaning that **lessons learned** would be forgotten. Due to changes in cabinet and governments, the lack of institutional structures does not allow for continuity.

> *"A lot of people, actually, that were there, were key persons in the pandemic that might not be in charge anymore during the next pandemic. And I don't think that they all made really structural documents and plans."*

> *"Nothing is institutionalized. It's all dependent on the individual persons that are in the higher levels."*

Finally, although advice was shared, there were no obligations to implement the research advice provided. Research could be done but in order to enforce it, researchers would need to be convinced that it is valid, useful, and necessary.

> *"I think researcher should be let free. Research is such an amazing thing, such a pure thing (...) it should be helped afterwards to be translated at policy level. It's really how society uses research rather than putting the blame on research on how it communicates itself."*

Table 1: Summary of Reported Challenges emerging from the Interviews

Summary of challenges	Misinterpretations and oversimplifications	Understanding models	Uncertainty	Unclear roles and responsibilities	Accessing information	Competition in research
	Understanding the reasoning behind decisions	Sustainability of lessons learned	Negative emotional reactions	Widespread misinformation and disinformation	Timing and availability of information	Bad quality of data and research

Opportunities/ Actions recommended

1. Enhance the understanding of the overall picture

1.1. Know the political context and the stakeholder landscape

To address the confusion and frustrations that arise from misunderstanding the reasons behind decision-making, **getting familiar with the range of stakeholders** that influence policymaking would enhance understanding of the complexity of decision-making. This must include understanding different mandates, roles, and responsibilities. Also, recognizing that roles will and should evolve in the course of a crisis is essential in remaining adaptive. As a crisis evolves, so do needs and responsibilities. This can also explain the need to adapt the composition of advisory boards, such as including more social scientists in later stages of a pandemic. These changes should be communicated broadly.

"It's also having an overview of what our research does and how it impacts (...) it would be necessary for researchers to understand these different agendas."

"I think having the hard knowledge isn't the issue. (...) What's really important is understanding all of these institutions that work together."

"I think that links back to the landscape and trying to know what's going on here, locally, regionally, and on the higher level; European level, and national level."

On the other hand, policymakers are encouraged to be trained in science literacy. Additionally, both groups would benefit from receiving civics training. Promoting 1) policy understanding, 2) science literacy, and 3) civics will require **incentivizing continuous education**.

Due to the panoply of actors, **power dynamics** are highly relevant to understand: which stakeholder influences the government more or less?

"We should not be naive at the same time to think that it's only a matter of making research as good as possible. Because even if the research was the best communicated, the best research, the most affected, the best P value you could ever have, eventually, there will still be the problem that the policymakers prioritize something else over scientific evidence (...) but we should not give up completely any hope of change or any hope or saying that all the policymakers are yet terrible."

"I think that a very strong assumption we have is that policy decisions are not taking (advice) because of ignorance of certain research, rather than they are willingly not taken because of interest."

"Many policymakers, they are not ignorant, they know very well what the evidence is. They know very well what is better for the people's health and they are willingly and consciously deciding to prioritize other points. And so, I think that if we do not take this into consideration, we will remain in a naive spectrum."

A better understanding of the policymaking culture can also be reflected by offering **wider choices and scenarios for policymakers to choose from** according to their respective political colors. The scenarios would remain scientifically valid by remaining evidence-based, but the research would reflect the needs of policymaking by offering wider options.

1.2. Clarify mandates, roles, and responsibilities

The advisory boards need to know what kind of information they can advise on and their scope. This includes clarifying definitions for crises (short, medium, and long-term crises) to ensure topics are not forgotten, such as PFAS, AMR, mpox, and mosquito-borne diseases. The bodies receiving the information must also have stronger and **clearer mandates** to understand where to refer the information to and to know who ultimately makes the final decision. Mandates can support role delineation to keep advisory boards in their advisory position while ensuring that their advice is heard by the adequate receiving end.

"It was clear that for these kinds of zoonotic problems, one health problems, there is a lot of things to solve. So I don't think, I'm not quite sure if the timing of communication was discussed very much in detail, but risk communication for those topics is definitely something to discuss."

"I think if we were to have a crisis again, well, when we have another crisis I would say actually, is at the beginning it could be very beneficial for everybody who's involved in the different roles to get an introduction to what it's like to have that role, right."

Some **built-in flexibility** was recommended as some regulations might not always be adequate and institutions like hospitals might need to adapt. Ensuring that authorities do not transgress their scope of authority and preserve the independence of hospitals is essential. Similarly, protocols need to be made so that they allow flexibility in adapting to the local context. This connects to the idea of avoiding a one-size-fits-all approach where a guideline would be produced containing the main principles, and these would be further refined for the targeted groups.

“What we have had to do is to optimize the protocol to work in our laboratories, instruments, enzymes, and the setup for these tests that we have in our laboratory.”

"We know that if communication resonates with people, they feel like it fits them, they understand it, they believe in it, they trust it - and I don't mean just trust that it's correct, but trust that if they do something they will benefit from it."

Assigning clear roles can also maintain networks and structure communication to maximize their use and sustain them through time.

"Repetition of the meetings, of course, because in many cases we have a brilliant start about something, and then it starts to fade out. So you need someone to be responsible for that and keep up the meetings and the good work on that and, of course, to be open to give your results and don't hide things."

Finally, model-based **scenario-driven exercises** are recommended to help trigger questions and thoughts on alternative futures. This can be very helpful in identifying gaps. **Creating training** that can mix scenarios and lectures that would incorporate a communication flow exercise, such as 'Who to turn to with this information?' and 'What information should I provide where?' would be helpful, and would put emphasis on the value of dialogue. These trainings should ensure that they do not overlap with already existing trainings made by the EU.

"It really helps this kind of scenario-driven exercise because you really discover, I mean, what are the gaps."

"Building scenarios and trying to make people project themselves into an emergency scenario allows to seed a couple of problems that they would not see in peacetime. (...) So the first time you need to respond to an unpredicted situation, you create chaos (...) I think this is what you need is to create sometimes shock."

1.3. Clarify the scientist's role

Because scientific experts are limited to providing advice, as the pandemic evolves and the needs change, the role of scientists in the media and communication must adjust. As mentioned previously under 1.1., as pandemics evolve, needs move from being purely biological to more complex societal questions that involve economic and social factors. In this case, health scientists who are not responsible for decision-making must leave space for other scientists from social sciences or other representatives. Indeed, as the pandemic evolves and population needs are voiced, the advisory groups must diversify to incorporate more psychologists and social scientists, such as economists and anthropologists etc.

"Most of those people were just scientists, researchers, and academics that had nothing to do with policy-making, et cetera. So, they were understanding the virus, they were understanding the dispersal patterns. They were understanding the relative risks, etcetera. But they had nothing to do with applying these decisions and measurements."

However, some interviews reported that this role should be carried out by scientists if levels of trust in governments were low. Indeed, **trust in governments** was reported as highly important but interviewees did not offer suggestions on this point.

"One of our roles was to explain to the media the decisions that were taken by the government. As for the French public, it, as you know, the trust in politicians is not very high and having so-called independent experts explaining the decisions was viewed as important."

When decision-makers decide to **reject scientific advice**, they should be able to explain why they do so. This is also connected to building trust.

"They don't have to agree with what we propose, but they I feel they have to comply or explain than what they do."

"I believe in people being experts. I am an expert on doing research on infectious diseases. A doctor is an expert on treating infectious diseases. What the message would be to deliver to the people should be given by somebody who knows very, very well the rules of communication of how you get across. So it's not a doctor, it's many people that have to work together and try to understand each other. So each other have to explain their own view. Me as a doctor. Me as a research scientist, me as a politician, me as a health worker, me as a publicist, as a, you know, public relations person. They all have to sit down and talk and decide on what is the best way to actually convey this information. Don't think that we can convey the information just by being scientists, or if a politician and a scientist sit down together."

1.4. Translating science into actionable and relevant advice

To avoid misinterpretation, scientists can contribute by attaching to their results a few tangible and **actionable steps** to follow. Results recommended not only stating problems with accompanying such statements with proposed solutions. Indeed, **translating** the meaning of scientific data into **what it implies either to policymakers or healthcare professionals** can clarify the impact of such information on daily management, such as patient stratification, patient management, and care.

"Now the reason why it's not clear enough for a lot of people is cause a lot of people don't understand that you need to have the conversation. I mean, there needs to be a conversation between politicians, policymakers, and the people that give the advice, the experts. Because if you don't then the experts could come up with very strange and nonrealistic ideas and then policymakers, they would not take such advice because it's just not doable. They can come back to you and say, 'OK, this is not possible so can you come up with something that is possible or feasible?' I think that type of conversation should occur. But finally, the responsibility at the very end is the policymakers."

Indeed, explaining the implications of epidemiological information to HCW supports them with decision-making related to resource allocation of beds, ventilators, and management processes of patients and discharges.

"If you would have interpreted the policy, you know, to the letter, what would have happened is that there would not be enough personnel to be able to cater for all the patients (...) So you know that the policies that were good but not that good. There were ways to circumvent (the policies) that I was sufficiently confident that, you know, if they would come and verify if the policy was followed, I could argue."

"We need to be able to provide some flexibility in the system."

When making these decisions, it is recommended to remain aware to what extent the population will accept the measures adopted. This is linked with recognizing the policymaker's need to consider public adherence to measures.

When offering solutions, it helps strengthen and build trust.

"In this frame analysis, I like to see how different stakeholders influence how we talk about the topic to then influence the decisions that will be taken (...) Basically, if you work in a project or in a three, four, five year project, then the problem is that it's sustainability. So you produce all these and then what? What happens afterwards? And so you try to connect it to (...) the relevant DGs, to those who take the decision. To make sure that they have the information and that your results influence the agenda afterwards. "

2. Alter communication channels

2.1. Create space for dialogue

To avoid misinterpretations, promoting spaces for the exchange of information in a back-and-forth movement can offer the opportunity for policymakers to ask questions, verify if they understood the advice adequately, and offer the opportunity for scientists to **validate their understanding**.

"So, actually, with regard to communication, it's just using these scenarios to train to become aware of the fact that communication is not perfect, so, and then starting to repair as you communicate."

Additionally, it can promote the scientists' **understanding of the policy needs** to further **refine their advice and modeling,** recognizing that policy must weigh many different things and not only rely on scientific evidence for decision-making. By being more **targeted, realistic, and contextual,** scientists would have the potential to be more influential, and, on the other hand, policymakers could become more accepting of advice and other scientific communication.

"But it's not so much about the content, but it's how it's shared. So, making sure you have you know a clear message that highlights the uncertainties and key assumptions and making sure that the people who are going to read and use this can (...) understand, you know, the key messages and key points and ask questions so that is no confusion about what we say or what the modeling means."

“The lesson learned there is that we gave one advice with a little room for selection, let's say. So what I would ideally hope for, in the next time around let's say, is that, and certainly on terms of pandemic preparedness, that you can actually propose different options and then they can depending on their color, their party and so on, they can still actually maneuver around and discuss amongst each other."

HCW reported that research, and particularly models, help guide more refined planning and allocation of resources.

"We were able to make projections long term. You know, I was able to make projections maybe 10 days from now. But with a system then we managed to have something more solid. "

Creating space for dialogue connects with **the need for research to meet policy needs**. Researchers must be strategic when communicating to ensure that their research is **relevant**. This requires knowing where your research fits in the policy agenda and framing a research question **that comes from a policy need**. This method also acknowledges the complexity of the decision-making and the multiplicity of stakeholders involved. By recognizing that evidence is not the only driver of policymaking, research visibility becomes ever more crucial. The interviews conducted during this research do recognize the difficulty that lies in creating clear and short messages while preserving scientific validity.

"In this frame analysis, I like to see how different stakeholders influence how we talk about the topic to then influence the decisions that will be taken."

"Once you know that, you know their boundary conditions, they know our boundary conditions and we can meet halfway."

This dialogue space allows researchers to support the interpretation of results and **clarify the take-home messages.**

"You kind of, let's say, sharpen the thinking of what is best to communicate and what the situation is and what to expect because there is that peer conversation going on the whole time."

For the dialogue to be successful, it requires a lot of listening.

"I think it's also that they were tired and that they didn't feel listened to. And I think that's one big part of communication (...) this communication which is listening to people is a very, very important one."

"So, actually, when you talk to policymakers, they need to convince them. First thing is listen to them. Let them explain to you how difficult it is for them. The power of listening. That's not new, you know, but it is very important. Give them time and give them a voice to express how they live the difficulties."

If academic research could better target policy needs, this could enhance policy-makers uptake of academic results. However, **preserving the "pureness" of research** remained highly important meaning that research for the sole purpose of research must always remain; but that it should also be balanced with responding to policy needs for society. This could be reflected through mixing 'free' research agendas and strategic-based research.

2.2. Allow space for feedback

Opening channels creates this **two-way path for communication which** allows dialogue but also space for feedback to maximize the influx of information. This space for dialogue also allows **space for criticism,** which is needed as no decision is perfect, especially in the context of crises, but it remains crucial to focus on what has been done and where to go forward instead

of having a dialogue session on complaints. Sharing solutions is especially necessary when inadequate information or behaviors are circulating. Explaining why these are wrong must come along. Feedback is essential, as not everything can be predicted.

“I have our communications team, and so sometimes I write something, it goes to them, they butcher it. I get extremely upset, and then we start this fight where I want things to be kept in, and they say like, ’No, we have to make it shorter, we have to make it snappier. ' But at the same time, we work in this process that it's like sort of a ping pong, back and forth. Well, eventually, at the end, I think we get off into a compromise that works."

This is also necessary between research fields. For example, if laboratory networks communicate among themselves, there can be a representative elected to serve as a bridge between the field and the policymakers deciding what information should move forward and be communicated to policymakers.

Feedback on progress is also necessary, as stakeholders must be made aware of the impact of their actions and be **rewarded**. This can serve as encouragement and also regulate emotional reactions.

"You can immediately see who gets, like, who is used to getting feedback, if they all of a sudden become insecure, they're not used to being challenged."

Feedback also allows scientists to ensure that their message was not misinterpreted, and it provides them with the opportunity to adjust or rectify policymakers' messages, especially if there is a loss in layers or nuance.

“We were talking with vaccination centers through a WhatsApp application, so if they had a problem (the vaccination clinics) about something, they would pose questions to us and we would just answer to them.”

Practice and training on the **communication of epidemiological and decision-making models** would highly benefit researchers to enhance their understanding of such a tool, especially regarding the **management of expectations**. There are limits in forecasting, and these must be clearly defined. Predicting shorter timelines has been shown to be beneficial. Training on **communicating risks** and outcomes of models would benefit the field of vaccination by enhancing the understanding of the vaccine’s capacity and reinforcing trust in vaccines. An interview suggested using the influenza model rather than the measles model when explaining the COVID-19 vaccine.

“I think it's an obligation to show to the public that we know what we're doing and we're going to do that for your benefit, you know, and under the pandemic crisis, this is a little bit tricky to do and quite difficult to do, you know. I think it requires people with special skills and also people with special training.”

Allowing space for feedback enables policymakers to share what is acceptable or not to them.

Finally, feedbacks are also needed within **transdisciplinary teams** to ensure that knowledge is understood by co-workers. Practicing sharing your research to researchers in other fields is good practice and can help understand how your field is perceived by others.

"I could say that this kind of preparedness meetings that involve different specialties is something that is helpful because you can get the different point of views and get all together."

2.3. Change the focus lens

Instead of focusing on communicating the details of the measures put into place, results suggest **focusing on key principles** of pandemic protection.

"Make this invisible virus visible to the people, and that will allow people to adapt a bit."

Indeed, policymakers should focus on sharing information about how **airborne transmission occurs and how to break transmission** rather than on harsh, authoritative containment measures that might be overly specific due to high levels of uncertainty. Focusing on key protective concepts rather than specific measures would also enhance critical thinking.

The content to be promoted in general includes the following:

- The interface between policymaking and scientific recommendations
- Viral strains and the introduction of new strains and introduction events,
- Patterns of spread and how they influence the severity of a situation,
- Exponential growth and dynamics of epidemics to understand the need for anticipation
- Promoting the understanding of countermeasures (their efficacy, the amount needed, and the process of development). Clarify not only what the countermeasure is but the range and extent of its role,
- Promoting the understanding of management aspects as well would require understanding surge capacity, laboratory capacity, quality of tests, reagent availability, vaccination for certain personal backgrounds, boosting vaccination and vaccination post-infection,
- Improving the understanding of uncertainty, probability, variability, and relative risk.

In the case of HCW, these are highly trained professionals who already understand complex concepts. Trusting that they can follow key principles might be better suited for this stakeholder group rather than changing guidelines very frequently. Sharing how **the concept of transmission** can lead to different outcomes rather than specific measures promotes leveraging already existing cognitive capacities.

Researchers can support this by offering an **epidemiology master class** not only to policy advisors but also directly to policymakers. This training would focus on the key concepts, not the measures, and would emphasize the wave-like motion of pandemics to enhance the **understanding of variability**. Emphasis on explaining the effects of stopping containment measures was reported to be highly needed when sharing models and when providing training.

"What I think is really essential is to teach them about anticipation. (...) That really you need to take measures before your hospitals are starting to see patients."

3. Enhancing the visibility and applicability of research

3.1. Altering the research business model – Promoting networks

"(create) a different culture in research land."

Changing incentives away from the quantity of publications to the quality and quantity of networks and communications might put more importance on making research available to the target audiences. Shifting the focus from quantity to **quality of academic writing** in order to promote research excellence over the number of publications could reduce the creation of "garbage research".

"They have the expertise, but they don't have the experience and I think I'm still struggling how to deal with that because you don't want to rule them out. I don't think we have the right to rule them out as such, but at the same time, I've had some experiences with groups that that really want to be yeah at the forefront and are basically there to showcase that they're important rather than to do the work."

Altering the business model could also **reinforce the need for networks and collaborations**. Having partnerships can avoid working in silos and offer better use of resources. There is value in collaboration by bringing in a pool of expertise. Incentives should aim to promote networks and collaborations.

"I think there should be more communication between the different groups because I think throughout the pandemic there has been a lot of overlap of repetition between different instances that were involved and that people have done a lot of, yeah, redundant work, in fact, because it was already done somewhere else, and that you were just not informed and maybe more and more clearer rule designation."

"So we had to be able to respond very quickly and the fact that we managed to get together all the key people, you know, not only were we able to advise, but also to take the decision and the responsibility and act, to me, I think was quite important."

This collaboration should go across borders, extending globally, to **align mindsets** on one common goal, and leverage the network to **work together instead of competing**. This can better validate the knowledge created before it is transferred to policymaking. The EU can play a central role in these global partnerships by offering funding to create and maintain these global research networks. Allowing people to connect can also contribute to having a more **systemic view** of an issue. This is helpful when considering logistics. Indeed, relationships and networks enable to leveraging of already **existing resources** such as connecting with the tourism sector to accommodate HCW in hotels or with the event sector to organize communication meetings.

"We had monthly meetings where we discussed the epi(demiology) situation in the different countries and just that discussion in its own was worth a lot more than some of the modeling exercises we've done."

In a specific case, networks were able to be quickly leveraged to troubleshoot problems. In the event of contaminated diagnostics that made all results positive, cross-country networks were able to rapidly inform one another.

“We had made a big order primers and we had a serious problem with everything getting positive and then we had feedback from other European countries that this was a problem from the industry that was preparing this stuff and it was a problem that many labs had at this period.”

Cross-country networks are also valuable as they can help inform decision-making when there is no evidence to work from by looking at how other countries respond. Although decisions are often not comparable due to embedded differences (health information systems structures and data links), it can become a source of inspiration to think differently and understand why countries manage the situation differently.

"We (the advisory boards of countries) *ended up talking to each other very frequently because we felt it was very useful to share our experience. Just already to analyze the situation, understand what was going on, our experience with the politics, I mean the political world, because we were all facing the same issues of advising them* (the governments).”

These networks were especially valuable when countries could anticipate each other.

"We had an example of Italy because, you know, our next-door neighbors when they actually found themselves with - from Monday to the other - with thousands of confirmed cases and hundreds of deaths and they hadn't realized what had happened, I know that the Greek policy makers actually took that as an example. And they said, ‘OK, we have to do something now that we have only a few confirmed cases’"

"So we had three weeks to adjust the models based on the data provided by the UK in the UK (...) we were in that fortunate situation where we could get the indicators and parameters from the UK so that that worked well."

To promote the efficiency of the meetings between and within networks, it is helpful to consider downsizing meetings as fewer people promote better discussions, and adding ad hoc unofficial meetings if needed. These ad hoc meetings can be useful when countries outside of the EU would benefit from learning from each other.

"It's the key for everything I'm telling you. You know we were prepared because we were members of the networks."

3.2. Changing the way of communicating research

To enhance research visibility, researchers must also adapt their communication style to their audience. This includes moving away from solely quantitative data to **promote qualitative data** in the form of narratives, and stories, leveraging metaphors, allegories, and ethical considerations. A specific interviewee reported the need to showcase the values that guide your research. This reflects the high value of making your research known to others.

"I think it's really about making sure in the acute moment of the crisis that your communication is understandable and not too specific."

"There should be somebody almost like the weatherman or the weather woman saying this is the state of the affairs with COVID (...) something like that to make it less political and less, let's say, imposing on the population. Just more information."

Making your communication more **straightforward** is also helpful by focusing on key points **repeated multiple times to build the right reflexes**. Results highlight value in **direct and informal** communication using Whatsapp groups or direct calls. Scenarios were reported as being useful in creating the right reflexes.

"The Whatsapp group that we had with all the vaccination centers proved to be very helpful. It did prove very helpful because the workers at the vaccination centers could get an answer within the hour or within, you know like 1/4 of an hour, 20 minutes. And it would be an answer given by a member of the Vaccination committee and a knowledgeable member either professor."

The communication technique must be adapted to the pathogen at hand.

"It's not always needed to have many meetings. Especially for influenza, that the epidemic has a very known development. You can have a meeting at the beginning, at the middle and at the end. So you don't need to have many meetings."

The speed of change was often reported as being challenging. Adjusting not only content and approach but also the **tempo of recommendations** to leave time for stakeholders to adapt. Managing speed remains crucial when needing to communicate a breakout data and timely procedures must be put into place.

"Because there is no value in trying to characterize samples and sequence and find what is different throughout the year if this is gathered up after the end of the epidemic season. There's no point. It's only the research purposes. You have to be able to deliver this information to break it out, and if something is important to take action on that."

"Decisions had to be quick and sometimes they were very contradicting and sometimes you couldn't get this information to the public at the right time and that created an awful lot of problems. A lot of problems because the public ... and we still pay from these mistakes. Because. I think nobody cares and you can see that in what is happening around the world nowadays. COVID-19 is still here. It still kills people, but most of the people around the world don't care about getting vaccination for COVID, and we even have a current government of the United States that don't even believe in that."

Although repeating information has value, reducing the number of communications can help reduce confusion. This requires recognizing that the duration of pandemics is non-negligible: **crises that act on a long term require different approaches than short-term crises.**

Speed of change is also challenging for the researchers themselves, as they can begin to doubt themselves.

"You know, when it comes to challenging times, where the information changes quickly too, you also discredit yourself by the fact of the day. You know, one day you say to the people you should go and vaccinate yourself, and the next day you tell them if you're a woman below 60 don't use the AstraZeneca and opt for the mRNA vaccine, you know, and then the questions start..."

Furthermore, to know your target audience better, you need to **listen** to them, get to know them, and **open up channels**. This connects with dialogue, feedback, and networks. **Empower** the researchers to connect with policymakers and to be part of the debates so that they can clarify how their research can lead to impact and be relevant. Although it should be a shared responsibility, especially in times of crisis, the results report that researchers must be responsible in taking to leap towards policymakers. By leaving out of their bubble, researchers can improve their understanding of the policy world and the EU jargon. This can also apply to the HCW world and their jargon.

"But most researchers don't have that celebrity status. And they have to be proactive to get some visibility to be there. And that's why I empower researchers to get to know policymakers if it's relevant."

"So if the scientific research often supports a certain agenda then it is a responsibility as a researcher, as Community citizen, as NGO to support as best as possible, the policy makers that I go in that direction."

"You need to actually interact on a policy level if you want to convince policy."

3.3. Independence of research

Ensuring that the people chosen to provide advice are not affiliated with the government is necessary to provide credible scientific advice. This can be done by making the results publicly available and publishing them quickly to the general audience as well as ensuring that researchers are able to decide on the topic researched.

Having information directly conveyed to the head of the state may help avoid misunderstandings and preserve evidence.

"One of the points we found important was that we felt we actually were able to keep our independence from the government, and that was a very important point. If you work for a health agency, you respond directly to the Ministry of Health usually I mean you have this channel of authority with Minister of Health and I think it is difficult for the health agency in times of crisis to sort of take the distance from the government because you are in the middle of a crisis and they are directly your boss, I mean, the minister of Health is your boss. The second reason why we were independent is that we were talking directly to the President of the Republic, to the head of the state. We were not going through Ministry of Health and different channels (...) But basically, we were bypassing the usual chain, you know of command, and that made our work easier because we were connected right to the top (...) The good thing is that we were not subject to the Ministry of Health, digesting our information, transforming it, and making it to that. We were right-branched to the top."

However, it was reported to encourage building partnerships between public health agencies and researchers to promote synergies in times of crisis, which can be very helpful for epidemiological and scenario-based modeling. Establishing these connections during peacetime can help resolve barriers before a crisis hits. Indeed, researchers hold the advantage over health agencies during emergency times in that they function in less hierarchical and less rigid systems, which enables them to quickly use data, making them better equipped to deal with crises.

"I think one way is to embed into health agencies some research units which are partnership with research institutions (...) They have so much to do and all those things require some regulatory approval to have access to sensitive data and stuff. So it's in peacetime that you can do it. (..) I believe some partnership with research institutions can help because then even in the time of crisis the legal aspects have been solved and the data can be shared and the scientist can be more reactive. "

4. The power of connection and relationships

4.1. Trust and Transparency

Being **transparent** about the uncertainties to build credibility and trust. Building **trust** was reported by most interviews as being crucial in creating robust and open relationships. It allows a space to listen to different points of view and better understand one another.

"I had some legitimacy because I had worked before on coronavirus. I had some knowledge based on my past experience."

"I think that the way of the way that we communicated has somehow been incorporated in our everyday life. So the pandemic had this positive impact, let's say, in our everyday scientific life we are much more positive and flexible in communicating with large concerts here and via Zoom meetings etcetera. That was really not the case before the pandemic."

Networks are also crucial as they enable researchers to further create knowledge **and ask questions** rather than waiting for publications. This is facilitated when people already know each other. Regularity of meetings enabled us to create safe spaces to ask difficult questions, especially for HCWs.

"It depends very much on the on the scientists that try to collaborate. We have two or three scientists that we know each other so we can collaborate better and with people that you don't know."

"We were trying to actually partake in meetings, virtual meetings at that time because we could not meet in person and also give talks. I gave numerous talks to people working as scientists, biologists, biochemists and pharmacists or the rest of the vaccination committee that were medical doctors which go to their respective specialty and sort of give them, you know, like seminars and try and talk about these questions, hoping that the information would go down to the patient level. If you see what I'm and also required we try to do that."

These networks should be composed of **transdisciplinary** panels and have a panel that evolves as the needs evolve. Adding expert representatives from various fields **preserves the layers**

and the nuance and helps consider societal needs as the pandemic evolves. It was reported that previously established networks helped during a crisis as people already knew one another. Although transdisciplinarity might take longer for discussions to reach a consensus, it avoids extreme decisions.

"This kind of interaction will be very helpful, and it is something that this year we try to have for influenza. We try to have some meetings with all the parts involved from the reference labs, from the epidemiological part and from the public Health Organization, the heads of the departments so that we can organize better the way the results that we get from the characterization of the viruses through the year are delivered to a central office, let's say, of the public Health Organization and in case something is important, we can have more direct action on that."

Good relationships help build trust which is needed to enable dialogue and feedback loops which contribute to more informal communication. This includes good relationships with the media. These networks can be used to ensure the **quality of information** and content communicated.

"There was an awful lot of deliberation among the Vaccination Committee members about the quality of information that we would be getting. Our judgment was based on publications, but it was also based on deliberation, with people working in international organizations. I mean, at that time we would watch also the Committee meetings of the FDA or committee meetings of the German Society and of the British Society, or the French society, and see you know how we could encompass all this information."

This cannot replace the need for **media and communication training** for all stakeholders to speak publicly.

"School curriculums need to address, you know, information literacy, science literacy, and that includes, you know, how to how to detect misinformation, how it spreads, and what the difference is and – misinformation and disinformation, they're not the same thing. "

Additionally, misinformation and disinformation should be better managed vis-vis the HCW to avoid the spread of false information from such important and influential figures in society. Indeed, some safe spaces should be installed to offer HCWs the opportunity to discuss fake news and misaligned information within hospital settings.

"I also think that there needs to be some sort of oversight, right, so you keep your license to practice medicine, and you have to adhere to a code of conduct, right? So part of the Code of conduct should include that you don't spread misinformation that causes harm. I mean, otherwise you, you know, you violate your Hippocratic Oath."

Finally, networks can **leverage the online channel** to enhance communication.

"Also, what is very helpful that was introduced with the pandemic was were the online meetings, because all this now we have much more communication with our foreign collaborators than we previously had. Everyone is very familiar with this type of communication and it's really helpful. Of course, I wouldn't say no way that this could change

the face-to-face meetings because this is also very important, but in everyday life it's a very helpful and very easy."

4.2. Empathy

The networks and dialogue contribute to sharing empathy. Acknowledging hardships, understanding that there are exceptions helps reduce the negative emotions fueled by infodemics. It can also help build trust towards the scientists and governments to enhance behaviors that accept information from scientists to validate or reject information read or heard from the news. Avoiding blame, nuancing and promoting rational discussions was helpful and scientists held an important role in that.

"But we all have this, its normal human behavior. It may depend on the time of the day that you're tolerant or not tolerant, and someone can be tolerant in the morning and very intolerant in the afternoon, the same person. It's like children. There's no bad children. Sometimes children behave badly."

Scientists were reported to play a crucial role in reassuring the general public and in keeping emotions under control.

"I tried to be very calm and very restoring and not exaggerating, but state the facts"

"You want to instill at the same time a certain calm to deal with an otherwise complex situation."

5. Structural Change

5.1. Systemic Change for Research Implementation

Structural change to build networks will facilitate more **intentional knowledge production** as opposed to incidental.

"We cannot even start training yet. I think there should be something more structural". (for communication)

"And this has to come from the (people) responsible for that, but in in this case it started from the reference labs that we asked for this kind of meetings and we asked to organize a better system for the information to be spread out so. OK. It's not bad to be someone's initiative to start something, but it couldn't be always an initiative. It has to be a way of thinking when you're in the public health sector."

" We focus too much on what the researcher could do to make it easier, research more relevant rather than demanding the system to create channels for our research to be better implemented afterwards. So it's a systemic problem to me, not an aspect of research (...) So I know it gets almost to the sort of utopian discourse, but at the same time, for me, it's also important to discuss. I always discuss normative terms because for me, if we don't discuss about our society should be, then things will never change."

It can also make sure that capacities for communication and trans-disciplinarity are built during 'normal times' as opposed to waiting for emergencies.

“I could say that this kind of preparedness meetings that involve different specialties is something that is helpful because you can get the different point of views and get all together and try to find a good way of communicating between each other. And maybe at this point that we are now this kind of meetings doesn't have an actual evident result because we are not on the this kind of phase of a pandemic or something very urgent, but still people will start to learn how to communicate with each other and this was something that I think that was really missing during the pandemic. Now we are much better on that.”

5.2. Improving access to data and data infrastructure

"That's if we don't data, we're out of a job or we can't play our role. That's clear. So the data is the crucial. Without the data, there's no need to have a conversation either."

Data access and data flows must be restructured to ensure that policymakers are also as highly informed as possible. Indeed, having access to as much data as possible can **equip** policymakers to make decisions based on priorities. This requires **strengthening real-time data collection** systems, especially e-health and IT systems, to have data of good quality and data coming from the community, as there is not only value in receiving numbers but also qualitative data from society.

"Because managing a crisis, such as that one, is really about making sure that you take decisions in a highly informed manner. And so, it's based on data, information, numbers, and so on."

"I would say ‘ if you can measure you can manage’. That's my motto."

When real-time data was available, results appeared very fruitful for management.

"They managed in just, you know, a couple of weeks to set up a fantastic dashboard that we were able to utilize and was very useful in managing the situation and in determining, you know, what, where to put our effort and how to engage or how to adapt the resources that we were investing in the whole thing."

Access to information on the following was reported during interviews: number of COVID tests performed, number of positive COVID tests, number of patients in hospital in total, number of COVID patients in hospital, number of COVID patients using ventilators, oxygen supply, beds available, FFP masks stocks, supply and protective equipment (masks, gowns, gloves). Indeed, if more access to COVID-19 hospitalization data had been available, it would support 1) the retrospective reconstruction of dynamic cases to estimate the hospital burden, and 2) provide an estimation of the reproductive number to estimate the proportion of people ending up in hospitals.

"I mean for future pandemics, assuming it will have an impact on hospitals, it's going to be severe. Really, the focus should be on hospital data, very clearly quickly. You can have a good idea about by geographical area what number of new admissions you have for that disease. The wastewater can be helpful to give you trends, but it's very difficult to convert wastewater in number of cases you know. And it will always be very difficult I think. But the hospital data

can give you a lot for the modeling with the trends in addition. The idea is 'will the hospital system resist or not'?"

The fact that no interviews mention the role of HCW in data collection highlights the need to emphasize the crucial role played by HCW not only in informing patients and providing care but also in serving as data producers and data collectors.

Harmonization of data is also helpful to avoid confusion, especially between labs and hospitals. This helps clarify the management process from test results, to contact tracing and patient prioritization.

Data access is also crucial to feed the epidemiological models.

"The only advantage now is of course they (policy-makers) understand also better how we are working, which data we can provide (...) see now more the power of a large networks of separate laboratories, what they can do, how they have to work with them. So there, yeah, I think the policymakers on their part have also learned a lot."

Data infrastructure also includes **clarifying the flows of information between people** following a structured plan, incorporating intermediate structures, and feedback. This can enable archiving knowledge as well. In some ways, interventions implemented during the crisis time were reported to be useful to implement in 'normal' times as well.

"There's also a system, an electronic system, a digital system created by the Ministry of...Its the ministry of information I guess it's called. So as soon as somebody would get vaccinated, there was a digital record. So the Ministry of Health knew exactly how many people had been administered, which vaccine, when was the time to get the 2nd boosting vaccination or the 3rd, and actually, to also get the paperwork that said that you have been vaccinated so that you can travel, or you can use that vaccination verification you know, for business or something like that. It's unfortunate that in Greece we did that when the COVID vaccination was adopted, and we still haven't have that for children's vaccination or older people, vaccinations, adult vaccination. It's quite funny that we know exactly how many people and who will go to what and how many times he got or she got vaccinated for COVID but we don't know the vaccination coverage for other very important diseases in the in the children and adult population."

Finally, finding ways to **tackle fake news, misinformation, and disinformation** is central to the question of data access, to ensure that the data used remains of good quality. Interviews reported needing to regulate social media or ensure that there is an evaluation step between producing data and sharing information to have a quality control procedure.

"People were asking all sorts of things, and the media social media helped us on one side, but also not being regulated at all, everywhere, you know, the quality of information was dreadful. And most of the people, I think, get the bulk of the information from social media nowadays, which is really sad and bad and dangerous, I think."

However, the system must recognize the inevitable delays in data access and that emergencies will always contain a period of elevated uncertainty.

“I think we will always have this very difficult first period when we have no data because we don't have tests. I mean, once you have something that goes into pandemic mode, you may need, I mean, thousands of tests, and at the beginning, it will always be in shortage. I mean, technically, you will be able to find your primers for your PCR, but having a test that is widely available is something that will always take a lot of time."

"We said oftentimes in our task force, you know that the absence of evidence is not evidence of absence. And that's a concept that is new to a lot of people, right? And that's something that I think we needed to be much, much more clear about."

5.3. Institutionalization of Knowledge

Knowledge and networks must be institutionalized to archive and preserve lessons learned to improve pandemic response in the future. These structures must be kept in place even during “non-emergency” times to sustain capacity. Making them generic would also enable fast adaptation to diverse pathogens. Networks must also involve and train younger individuals.

"They (researchers, expert advisors) were so overwhelmed that there wasn't a lot of knowledge sharing with the younger generation. So one of the questions is also 'How can we prepare the younger researchers? What needs to be done to transfer this knowledge that we now have from COVID? "

This is essential as interviews reported it was useful to have members of their team who had experience from lessons learned during H1N1, although it was on a much smaller scale.

Continuous knowledge training would be helpful to healthcare workers by continuing to learn how other parts of the world respond to and manage infectious disease outbreaks. This can be enhanced and **maintained through networks and relationships**. Indeed, already established networks of people who know each other are reported to enhance preparedness and response as they offer easier conversations that are more honest and open.

"I mean, we developed an enormous amount of respect for each other. We got to know people we had not met before. We, you know, we got to solidify relationships of people. (...) It was extremely respectful and so much so that after the task force ended, after our mandate ended, then we kept up an initiative called the Science Exchange."

"In fact, our government institutionalized, I would say, just because they made it very clear they formed now a very small group of experts primarily coming from our task force there (...)and they list the processes they will follow, they're sorting out who they call on for which activities, how do we really get science and policy to work to work better together next time around"

Way Forward

Most of the interviews agree with the literature search findings. They, however, add more depth, insight, and additional recommendations.

The challenges and opportunities are summarized in the following table:

Table 2: Summary of Reported Challenges and Opportunities emerging from the Interviews

Challenges	Opportunities
Difficulties understanding the reasoning behind decisions made by policymakers and what influences them.	**For researchers and healthcare workers:** Understanding the range of stakeholders involved and their power dynamics. Understand the subjectivity related to policy making. Understanding the need for policymakers to consider public adherence. **For researchers:** Practice creating frame analysis when conducting research. Translate implications of evidence into actionable steps for HCW and policymakers. **For policymakers**: Recognize that one policy might have diverse implications when put into practice. Provide justifications for decisions. Understand the various implications one policy can have on different stakeholder groups by remaining in dialogue with these.
Misinterpretations and oversimplifications. Difficulties in balancing clarity with nuance. + Difficulties understanding model assumptions and dealing with the prescriptiveness of models.	**For all:** Enhance the use of direct and informal channels of communication. **For policymakers**: Offer space for dialogues to create space for questions and feedback (critique, progress, and questions). Promote the understanding of assumptions, limits, and potentials of models while offering wider ranges of scenarios that can offer choice to policymakers as well as reflect political diversity. **For researchers:** Refine advice and decision-making modeling by understanding policy needs and circumstances. Empower research visibility and clarify take-home messages. Practice and trainings on the communication of models: clarify assumptions and the limits of forecasting, manage expectations. Make publications, data, and results readily available publicly.

Unclear roles and responsibilities led to confusion and disorganization.	**For all:** Initiate scenario-driven exercises and trainings to identify overlaps and understand communication pathways. Build reflexes. **For policymakers:** Mandates and information flows should be clarified. Clarify definitions for scopes of practice. Establish clear coordination between all stakeholders. Clarify how roles and responsibilities change during crisis time compared to normal times. Allow flexibility in the uptake of regulations. Clarify and maintain communication structures.
Challenges of remaining in the high levels of uncertainty and remaining in the unknown.	**For all:** Leverage cross-country networks and collaborations. Install transdisciplinary collaborations. **For policymakers:** Focus on sharing key principles, not specific measures. Receive training on science literacy, specific epidemiology concepts, and risk. Adjust the tempo of recommendations, and the amount of meetings to avoid overload.
Difficulties in accessing information	**For policymakers:** Promote access to real-time data to enable better anticipation and strengthen data infrastructure. Offer space for feedback on policies. Promote partnerships between public health agencies are research institutes. **For researchers:** Leverage networks and collaborations to anticipate and learn from each other. **For healthcare workers:** Promote harmonization of data Offer direct information on hospital data to inform policymaking.
Competition in research and data not being shared.	**For policymakers:** Create incentives to promote the duty of researchers to provide services to society. Change the research business model to promote quality over quantity. Promote global partnerships and research networks. **For researchers:** Promote networks and partnerships.
Making information not only available but accessible promptly.	**For policymakers:** Share protocol updates and inform hospitals of these changes. Install communication platforms between policymakers and HCWs.

Widespread misinformation and disinformation	**For healthcare workers:** Create consequences to the spread of information that is not in alignment with the main evidence. Offer spaces to discuss fake news and misaligned information within hospital settings. Offer and receive communication and media training for those speaking publicly. **For researchers:** Ensure credibility, legitimacy and autonomy of research. Make publications, data and results readily available publicly. Leverage networks to ensure the quality of information. Offer and receive communication and media training for those speaking publicly. Remain reassuring and avoid exaggerations. **For policymakers:** Remain transparent and honest. Be empathetic and avoid blaming. Create quality control procedures when going from producing data to sharing information.
Bad quality of data and research produced	**For researchers:** Uphold scientific methods, and research values even in crisis.
Negative emotional reactions and inadequate behaviors.	**For policymakers**: Avoid creating expectations that cannot be met. Remain honest and transparent. Be quick in responding even with high uncertainty, and avoid delays as these fuel fake news. Share feedback on progress and the impact of the actions taken. **For researchers:** Ensure the neutrality of the scientific advice and media representatives.
Challenges in the sustainability of lessons learned.	**For all:** Ensure that there is transmission of knowledge to younger generations. Maintain networks and communication structures through time. **For policymakers:** Incentivize continuous education. Install structural regulations that enhance the implementation of research advice provided. Institutionalize networks and archive knowledge.

It is important to recognize that informing, the reception of information, and knowing, the assimilation of information and what we make of it, are different. Science communication plays a central role in ensuring that evidence is translated, understood in specific contexts, and transferred into promoting critical thinking for adequate behaviors serving health promotion.

Conclusion

Science communication is broader than dissemination. The latter requires an extra step which is translating the scientific knowledge into an understandable end product to the target audience. It goes further than raising interest, it is about enabling the audience to decode the information provided and hopefully use the information in the best possible way. This flow of information can expose multiple challenges. However, specific actions are reported to help knowledge translation and support understanding. The interviews conducted highlight both challenges and opportunities.

The interviews looked into the communication dynamics between healthcare workers, policymakers, and academia during the COVID-19 pandemic as opposed to 'normal' times. It investigated the misunderstood concepts (what), the miscommunication events, the information flows (to who and where), the kind of information used and shared, the ways of communicating (how), and timing (when) to assess whether these had effects on behaviors and disease transmission. Exposing these challenges offered an opportunity to ask how can crisis communication be improved. These can support future avenues for improved pandemic preparedness and response.

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