



# The *in silico* medicine INFO KIT





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The authors acknowledge the fundamental contributions from colleagues from the EU projects in which VPH is or has been involved and namely In Silico World, SimCardioTest, SimCor, and EDITH-CSA. A special thank goes to our collaborators at the Life Sciences and Society Lab at KU Leuven.

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# Introduction

This Info Kit aims to provide an essential information package for the research community to **engage with key stakeholders** in the realm of *in silico* medicine. It provides guidelines on effective stakeholder interaction and includes information material, multimedia communication examples, focus group methodologies, surveys, and beyond. This document aims to **empower researchers** with a wealth of instructions and resources for navigating the complexities of *in silico* medicine stakeholder engagement.

In light of the above stated aims, the first version of this Info Kit primarily includes materials that facilitate **efficient dialogue with patient organisations** and patients themselves, as well as **clinicians** and other **healthcare professionals** - which are amongst the primary stakeholder groups for *in silico* medicine.

In the subsequent phases, we envision broadening the scope of this Info Kit by including tools and resources that facilitate engagement with other groups of stakeholders.

The document is developed by [VPH- The Society for in Silico Medicine](#) , an international non-profit organisation whose mission is to ensure that the potential of *in silico*

medicine is fully realised, its tools universally adopted and efficiently used in both research and clinical practice.

This Info Kit is a living document and, hence, will undergo regular updates, ensuring that the latest advancements in the field of *in silico* medicine are consistently reflected. **Every community member and stakeholder is welcome to contribute to this document.**

We appreciate and look forward to the developments and contributions of the research community, clinicians, patients, and other key players.

This work is developed as part of the EU-funded projects [SimCardioTest](#)® (H2020-SC1-DTH-2020-1, GA 101016496) and [In Silico World](#)® (H2020-SC1-DTH-2020-1, GA 101016503).

The resources included have been developed in the scope of said projects, as well as others, such as [EDITH](#)® (DIGITAL-2021-DEPLOY-01-TWINS-HEALTH, GA 101083771) and [SimCor](#)® (H2020-SC1-DTH-2020-1, GA 101017578). To request further information, or if you are willing to contribute to this initiative, please email [admin@vph-institute.org](mailto:admin@vph-institute.org)®.



# 1.0

## Stakeholder Engagement

Stakeholders' involvement is a fundamental step for the realisation, deployment, and overall success of *in silico* medicine. In this chapter, the reader will find useful information identifying stakeholders and target audiences, as well as which are the most useful ways to engage with them.

# 1.1

## Importance of stakeholder engagement

There are many reasons for, and benefits from, engaging with stakeholders in innovative projects, particularly in the case of *in silico* medicine. *In silico* medicine has the potential to transform healthcare and impact society as a whole by enabling personalised diagnosis, treatment and follow-up, amongst others.

**Stakeholders**, including patients, clinicians, policymakers, and industry representatives, **have diverse perspectives, understandings, and interests** that can - and should - inform the development and advancement of *in silico* medicine solutions. Therefore, it is crucial to include such stakeholders in all stages of the research and innovation process to achieve the best research outcomes in a process called **co-creation**<sup>1,2</sup>.

Involving stakeholders can also help to **identify potential ethical, legal, and social implications (ELSI)** of *in silico* medicine, and develop appropriate governance strategies to address such concerns within the community. ELSI emphasises the societal impact of **technology and innovation**<sup>3,4</sup>. Additionally, the **Responsible Research and Innovation**

**(RRI) framework** can serve as a valuable tool in the assessment of *in silico* medicine solutions, ensuring that the research and innovation process **aligns with the values, expectations and standards of society**.

By integrating RRI dimensions, such as anticipation, inclusivity, reflexivity, and responsiveness, into the development of *in silico* medicine solutions, stakeholders can actively engage in shaping the trajectory of technological advancements to **meet societal needs and values**.

This comprehensive approach, combining ELSI considerations with the RRI framework, not only addresses immediate concerns but also fosters a more **sustainable and responsible trajectory** for the integration of *in silico* medicine solutions into healthcare practices<sup>5</sup>.

Therefore, stakeholder engagement is essential to ensure that *in silico* medicine solutions meet the needs and expectations of all stakeholders and promote responsible research and innovation in the field<sup>1,2</sup>.



# 1.2

## Stakeholders of *in silico* medicine

In the realm of *in silico* medicine, the following key stakeholders are typically identified, all playing a vital role in the advancement of the field (Fig. 1):



### **Public at large:**

This category includes members of the society that have no specific knowledge on *in silico* medicine (citizens, taxpayers).



### **Patients and carer:**

Patients, their caregivers and the organisations that represent them.



### **Healthcare professionals:**

Includes all the medical professions and their related associations (clinicians, nurses, etc). They will be the primary users of the *in silico* medicine technologies.



### **Researchers in the *in silico* medicine field:**

This includes researchers in academia and non-profit labs. They are at the heart of the field, contributing to the research advancement. This category includes a diverse network of actors managing, coordinating, or conducting scientific research in the *in silico* medicine field, but also, science managers as well as students, the next generation of scientists in academia and non-profit labs.



### **Biomedical and simulation industry:**

This category is represented by healthcare industry trade organisations, and by individual experts from large medical companies (both pharma and medical devices), simulation software companies, as well as Small and Medium Enterprises (SMEs) active in both fields.



### **Regulators and conformity assessment bodies:**

Experts from EMA, FDA, national regulatory agencies and notified bodies. They are crucial in shaping the regulatory framework, essential for conformity assessment and regulatory approval.



### **Institutional stakeholders:**

Health authorities; payers; ministries of research, industry, and healthcare; research and innovation funding agencies; healthcare and social charities; other interested governmental and non-governmental organisations. An important subgroup consist of members of the (European) Parliament and Commission, and related committees. They have a key role in defining the (European) policies of relevance for the field.

This list is not exhaustive, it merely cites the groups that we frequently engage with. Each of these stakeholders possess different expertises and offer unique perspectives on the field. As such, **collaborative and multi-faceted stakeholder engagement approaches** are advised to ensure all stakeholders' voices are heard throughout all steps of the *in silico* medicine research and innovation process.

This acknowledgement underscores the dynamic and project-specific nature of stakeholder involvement, allowing flexibility in tailoring engagement strategies to align with the unique goals and requirements of individual projects.

Thorough consideration must be given when adopting the guidelines as they reflect extensive collaboration efforts, emphasising that merely implementing them without the necessary interaction with the intended stakeholders is insufficient for meaningful engagement.



Fig. 1 Stakeholders of *in silico* medicine

# 1.3

## Strategies for stakeholder engagement

Different stakeholder groups have **different expectations, needs and values** when it comes to innovation, which can be discovered through active engagement in a variety of ways, including one-on-one interviews, focus groups, surveys, and many more (Fig. 2).

As VPH, we are currently participating in several EU-funded projects on *in silico* medicine, where our main contribution is conducting effective stakeholder engagement activities, alongside communication and dissemination tasks, leveraging the awareness in the field.

Below, we provide an overview of the different strategies and examples of related activities we have conducted so far. The tools and resources mentioned alongside each of these strategies are elaborated in the subsequent chapters. Additional information will be made available in future versions of the *in silico* medicine info kit.



Fig. 2 Strategies for stakeholder engagement

# Strategy

## Delphi Studies

### What is it?

Conducting consecutive questionnaires with specific stakeholders, to gain a deeper understanding of the individual opinions, needs, values, expectations on a specific topic.

### VPH activity?

Delphi study were conducted within the In Silico World and SimCardioTest projects.

### *In silico* medicine context?

Delphi studies can be used to understand expectations, concerns, and preferences of a diverse panel of international and interdisciplinary experts in order to work out a Responsible Research and Innovation strategy for *in silico* medicine.

### Tools & resources?

[🔗Tool - How to conduct a Delphi study within the in silico medicine context?](#)

# Strategy Surveys

## What is it?

A survey is a systematic method of collecting, analysing, and interpreting information from a large randomised group of individuals to gain insights into their opinions on a particular topic.

## VPH activity?

Two rounds of a VPH-led clinical survey (2021 and 2024), to collect feedback from clinicians regarding their knowledge, experience, and opinions on the application of *in silico* technologies in clinical practice.

## *In silico* medicine context?

Surveys allow gauging the perception and mapping the landscape, as well as identifying barriers and opportunities for *in silico* medicine.

## Tools & resources?

🔗 [Tool - How to conduct surveys?](#)

🔗 [A peer-reviewed publication on the methodology of conducting and analysing a survey on the adoption of Computer Modelling & Simulation in clinics<sup>6</sup>.](#)

# Strategy

## Focus Group

### What is it?

A focus group, also known as a small group discussion, is a qualitative research method that is used to collect opinions and feedback from a small group of stakeholders who are carefully selected.

This allows the exchange of new ideas among stakeholders, from which they can derive added value themselves.

### *In silico* medicine context?

Focus groups can provide valuable information on the societal implications of *in silico* medicine solutions and identify possible barriers and challenges that come with the uptake of these technologies.

### VPH activity?

- One focus group during the general assembly in Bordeaux (France) on 21 March 2023, for SimCardioTest.
- One focus group in London (UK) on 22 May 2023 for SIMCor at the University College of London.
- Three focus groups for In Silico World in Leuven (Belgium) on 16 June 2022, and Bologna (Italy) on 8 November 2022, and Budapest (Hungary) on 12 January 2023.

### Tools & resources?

🔗 [Tool - How to organise a focus group on \*in silico\* medicine?](#)

🔗 [A peer-reviewed publication on the methodology of conducting and analysing a Focus Groups<sup>7</sup>.](#)

# Strategy

## Reflection workshops

### What is it?

Thematic workshop with participants from multiple stakeholder groups to jointly anticipate and reflect on the social implications of specific developments.

### *In silico* medicine context?

The workshops aim to prompt researchers and innovators to reflect and anticipate the governance of the social implications in their work and plan appropriate actions, in accordance to the principles of Responsible Research & Innovation (RRI).

These social implications are identified during preceding engagement activities, such as desk reviews, Delphi surveys and focus groups.

### VPH activity?

Reflection Workshop in Bologna, Italy, on April 19, 2023, for In Silico World.

### Tools & resources?

[!\[\]\(3cb60d42b10e53f9522bb0b392c1c4cd\_img.jpg\) Tool - How to conduct a reflection workshop?](#)

[!\[\]\(d0262bbe9d2356661a2e89321dfcc781\_img.jpg\) A peer-reviewed publication on the methodology of conducting a reflexive workshop<sup>7</sup>.](#)

# Strategy

## Information material and multimedia content

### What is it?

Learning materials to introduce a domain to a non-technical audience (self-reading/self-consuming – brochures, booklets, videos).

### *In silico* medicine context?

To inform/educate the wider public, patients or patient organisations, healthcare professionals on the scope and potential of *in silico* medicine. Such informational materials are fundamental to introducing an evolving domain.

### VPH activity?

The VPH is constantly involved in producing this type of communication material to be used at specific events, for specific projects and/or to be made available on our channels or through targeted communications.

### Tools & resources?

[!\[\]\(f95dab70c751fda7d824b8b03650f7aa\_img.jpg\) Resource - Glossary of \*in silico\* medicine terminologies](#)

[!\[\]\(e1c624d4757f08486e89482c18364c17\_img.jpg\) Resource - Library of curated multimedia content](#)

[!\[\]\(d8ab143e904bfa3467271eec5af75a9b\_img.jpg\) Resource - Success stories from \*in silico\* medicine community](#)



# Strategy Glossaries

## What is it?

List of terminologies designed to educate the community, fostering clarity and addressing definitional challenges, thereby enhancing awareness and understanding among stakeholders.

## *In silico* medicine context?

There are occasional confusions and diverging opinions on certain terminology which may lead to misunderstanding regarding the meaning of some *in silico* medicine concepts used in the literature. Having a common vocabulary is the basis for all engagement activities.

## VPH activity?

A team of academic and industry members of the [!\[\]\(e3f8612927870f2e0f9f5989e6dd3064\_img.jpg\) Avicenna Alliance<sup>8</sup>](#), including the VPH team, regularly proposes and updates a list of definitions used in the *in silico* medicine literature.

## Tools & resources?

[!\[\]\(17413706fd4997a1a4bdf85c6864eee1\_img.jpg\) Resource - Glossary of \*in silico\* terminology - why, where & examples](#)

Example: The white paper on [!\[\]\(faf942dc3e59ce8eb64b4ac481eca7e0\_img.jpg\) "The Role of Artificial Intelligence within \*In Silico\* Medicine"](#), summarise a non-exhaustive lexicon of terminologies on all terms related to *in silico* technologies, including several definitions for certain terms, whose definition defer subject to the community and the context in which it is used.

# Strategy

## Info sessions physical/online

### What is it?

Conducting in-person or online information sessions for a specific audience group at public conferences and events.

### *In silico* medicine context?

To inform and/or educate the public, patients or patient organisations on the scope and potential of *in silico* medicine.

### VPH activity?

The VPH organised a Patient and Public Involvement (PPI). [🔗workshop during the VPH2022 Conference in Porto](#)

The VPH contributed to the [🔗European Patient Forums' webinar series](#) on shedding light on 'AI in healthcare'. In particular, the session on 'AI in medicines innovation' enlightened how AI could improve or accelerate medicines development, and what the implications may be for patients. [🔗LINK](#)

### Tools & resources?

[🔗Resource - Presentation: Introduction to \*in silico\* medicine](#)

# Strategy

## Position/White papers

### What is it?

A short publication that presents the current state, problem and convincing solution related to a certain challenge.

### *In silico* medicine context?

White papers on the potential of computer modelling and simulation in healthcare aim to stimulate policy making, regulatory thinking and research strategies, establishing a perspective for the *in silico* domain, as well as help clarify boundaries and overlaps with other interdisciplinary areas.

### VPH activity?

The VPH actively collaborates with the Avicenna Alliance on a number of advocacy activities. As a result numerous position papers have been released tackling key issues for the *in silico* medicine community.

### Tools & resources?

Resources - Library of position papers on *in silico* medicine. Examples:

**2023:** Position paper on [“The potential of \*in silico\* approaches to streamline drug development”](#)

**2023:** Position paper on [“Public & Patient Involvement for \*in silico\* medicine”](#)

**2022:** White paper on [“The Role of Artificial Intelligence within \*In Silico\* Medicine”](#)

**2022:** Position paper on [“Toward a Regulatory Pathway for Using \*In Silico\* Trials in CE Marking Position Paper”](#)

## 1.4

# Understanding your target audience

Once the stakeholder map has been defined, and before undertaking any engagement effort, it is of utmost importance to **define, as specifically as possible, a target audience**. Subsequently, it can be defined where, whether live or in (social) media, such a target audience can be addressed.

Specific examples of different communication resources meant for different stakeholders, including the lay public, are summarised in the resource section of the Info Kit. This includes informative videos, podcasts, and success stories.

### 1.4.1

## The diversity of the lay audience

The term “lay public” refers to individuals who do not possess expert knowledge or professional qualifications in a particular field, such as *in silico* medicine. This term is independent of education level. Both a high-school graduate and a professor of medieval literature can have the same degree of unfamiliarity with *in silico* medicine.

Engaging with lay audiences is challenging because **this broad category encompasses a wide range of subgroups** with different ages, education levels, interests, and media consumption habits. The only common factor is their limited proficiency in *in silico* medicine.

Since no single approach can effectively reach all the diverse subgroups, defining the target audience during the planning phase is crucial. It's important to identify where the audience can be found and how to tailor messages to them.


For example, individuals aged 13-to-18 will have different interests, use different social media platforms, and respond differently to new technologies compared to those aged 55 and above.

## How to reach your lay audience on social media


Social media offers a way to reach a wide and varied audience globally. However, understanding the demographic composition of each platform gives a hint about which public can be referred to in each of them.


The data presented below were extrapolated from [Statista](#) and the [Pew Research Center](#).

Here are few examples:

 **Facebook** The largest age group on Facebook is 25-34, followed by 18-24 and 34-44. Users under 18 make up only a small fraction. Posts on Facebook should balance text and images, though large blocks of text and jargon should be avoided. Education level is not discriminant in this platform.

 **LinkedIn** LinkedIn stands apart as a career-focused platform, where users tend to connect with peers in their professional fields. The platform's user base is, on average, highly educated, with only a very tiny fraction composed of users with a high school education, or less.

 **Instagram** The largest age group on Instagram is 18-24, almost equal to 24-34, but the age distribution differs significantly from Facebook. The percentage of users aged 18-24 on Instagram is twice as high, while the 45-54 group is half compared to Facebook. Instagram emphasises imagery over text, so messages should be concise and integrated into the image, with very short accompanying text. Unlike Facebook, there is a higher proportion of users with college degrees.

 **X (Twitter)** On X, formerly Twitter, the main user groups are 18-24 and 24-34, with the 35-49 age group being much smaller. In this platform, there's a strong correlation between education level and platform use, with twice as many post-graduate users compared to those with a high school education or less. More recently, with the transition from Twitter to X, different user groups were impacted and changes are ongoing. Once available, updated statistics and guides will be integrated in the following versions of this document.



The background is a dark blue field filled with a network of light blue lines. Various white line-art icons are scattered throughout, including a DNA double helix, a laptop, a flask with liquid, a test tube, a document with a pencil, a human silhouette, a microscope, a heart, a lightbulb, a gear, and a hand. In the top right corner, the text '2.0' is displayed in a large, white, sans-serif font.

# 2.0

## Tools for stakeholder engagement

This chapter of the Info Kit introduces a collection of tools designed to help researchers assess the level of understanding and acceptance of *in silico* tools among various stakeholder groups. The tool of choice depends

on the stakeholder, the type of information needed, and the engagement opportunities. The chapter includes background information on each tool and provides practical guidance on their organisation and analysis.

# 2.1

Tool:

## How to Conduct a Delphi Study?

**Primary target group:**

Technology developers / Clinicians /  
Key Opinion Leaders

**Secondary target group:**

All stakeholders





## 2.1.1

# What is a Delphi study?

A Delphi study is traditionally understood as a systematic interactive technique intended to **collect forecasts or opinions** on future trends from a panel of experts.

The Delphi technique is primarily used by researchers when the available knowledge is incomplete or subject to uncertainty<sup>9</sup>.

Over the years, alternative approaches like Murray Turoff's Policy Delphi<sup>10</sup>, have aimed at structuring and **discussing the diverse views** of the preferred future, rather than reaching consensus among a homogeneous group of experts<sup>8</sup>.

Likewise, there are multiple Delphi variants (e.g. Real-time Delphi, Delphi Markets, Group Delphi, etc.) and processes that differ in the number of rounds, the selection of experts, the analysis framework and so on, which are best summarised in review articles on Delphi studies<sup>7</sup>.

This Info Kit presents the reader with the key guidelines to design and analyse a representative Delphi technique in the context of *in silico* medicine.



## 2.1.2

# Why is a Delphi study relevant for the *in silico* medicine community?

In the context of a fast-evolving domain such as *in silico* medicine, there is a clear need to **obtain stakeholders' opinions** on possible development scenarios.

This allows to **unravel common points and discrepancies** in how different groups of stakeholders forecast what changes will be taking place in the field.

A Delphi study can act as an integral part of these engagement efforts, whereby it not only builds on a preceding desk review, but also offers tangible leads for follow-up stakeholder engagement activities like group discussions and workshops.

Thus, a Delphi study can help **identify and address possible barriers** (social, ethical, regulatory, technological, economical, etc.) to the innovation process of a specific domain.

## 2.1.3

# Guidelines to conduct a Delphi study

These Delphi study guidelines show how it can be used as a means of engaging in a **two-way iterative dialogue** with stakeholders, serving as a basis to integrate user perspectives and concerns on the wider topic of *in silico* medicine.

To realise this broad scope, we outline a series of steps to help you define objectives, how to formulate the core team, practical aspects to organise and conduct the exercise, along with hands-on templates to get you started.

## Step 1: Define objectives

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Before working out the practical aspects for conducting a Delphi study, it is important to predefine the key objectives. In other words, **what do you want to identify or attain from this Delphi study?**

As you might note, a Delphi study is often conducted in order to **achieve consensus** regarding a specific topic. In other cases, the main goal might be to get a **deeper understanding of different perspectives**.

Here are a couple of example goals/objectives of a Delphi study that we have conducted within several consortia of Horizon 2020 research projects.

*“To solicit the expectations, concerns, and preferences of an international and interdisciplinary panel of experts about key elements that will contribute to the design of a responsible in silico medicine research and innovation strategy”.*

*“To enhance the participants’ social learning and reflexivity on ethical, legal, and social implications (ELSI) of in silico technologies”.*

The goals are operationalised by asking respondents which developments in *in silico* medicine they anticipate and wish to see (or not), and how society can best respond to voiced expectations and concerns. In other words, the possible outcomes of Delphi studies are to capture “expectations”, “perceived challenges”, “perceived opportunities” and “concerns”.

## Step 2: Assemble team

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Conducting a Delphi study involves engaging with **multiple stakeholder groups**. Whether it is identifying the goal, determining the methodology, preparing questionnaires or conducting a comprehensive analysis of personal opinions, all of these steps require a **multidisciplinary team**.

This is critical to acknowledge and strive for from the beginning of the process. For instance, to engage with stakeholders in a meaningful manner, involving and collaborating with Social Sciences and Humanities (SSH) experts is strongly advised for a successful outcome of the Delphi study.

A Delphi study may seem like a survey that technical teams can quickly put together and analyse through quantitative metrics. We caution that there is much more to it, as deeper insights are best captured in free-text comments, which require qualitative analysis of the connections and patterns between responses. That's why collaboration with SSH can facilitate such a deeper analysis of the outcomes, leading to **a better understanding of the underlying socio-cultural dynamics**, thereby enriching the study's impact and relevance.

## Step 3: Study design process

As outlined in the introduction, depending on the specific predetermined objectives of your study, **various methodological approaches and processes** exist to conduct a Delphi study.

To briefly recap, one could choose a multi-round consensus-based approach, whereby you present questions to experts and responses are refined through successive rounds of consensus-building. Alternatively, time-limited responses or a group-discussion format for querying can also be considered. Also, one could leverage the selection of experts, be it domain experts or a broader stakeholder group.

It is noted<sup>7</sup> that the latter approach of engaging a wider array of stakeholders is often interesting in the healthcare sector, where non-technical participants, like patients, bring their personal experiences to the table. There is no universally accepted way to conduct a Delphi study, each approach has its strengths and weaknesses.

Below, we articulate a few arguments in the context of *in silico* medicine, to help you navigate this important methodological choice, after having defined the objective [\(step 1\)](#) and team [\(step 2\)](#).

## Non-consensus:

In the context of a developing domain like *in silico* medicine, we believe that instead of trying to generate consensus, a non-consensus-based study design best presents the participants with a diversity of options and evidence for various perspectives that might, for the time being, even impede the formation of a consensus. Thus, stepping away from the conventional approach, one could aim to **understand (differing) viewpoints, expectations, needs and concerns** regarding *in silico* technologies.

## Choice of experts:

Given that the *in silico* medicine community caters to the diverse stakeholders of the healthcare spectrum, we believe that **engaging with non-technical actors**, beyond the core-technology experts, is paramount in every step of the technology development. Following the human-centric technology development paradigm, valuing the end users, be it the patient or the general public, as experts with real-world experiences, would likely bring out the much-needed risk-benefit balance<sup>7</sup>. This way, we can jointly embrace the future vision of *in silico* medicine technology, while addressing the concerns around trust in such technological advancements, ensuring that its development aligns with the diverse needs of the stakeholders involved.

## Multi-stakeholder:

Given the complexities of the *in silico* medicine ecosystem, a multi-stakeholder design enables comprehensive inquiry and varied input from stakeholders like industry, regulators, healthcare professionals and patients, aiding in synthesising key themes for the Delphi process.

However, we have also observed that the initial phase of the Delphi process benefits from a stakeholder-specific approach, with subsequent phases expanding to multi-stakeholder engagement. When transitioning from stakeholder-specific to the multi-stakeholder phase, make sure to adjust the language (e.g., limiting technical jargon), to make it accessible, especially to non-technical societal stakeholders.

### TIP:

In the context of using Delphi process within the *in silico* medicine domain, we advocate for an open-ended non-consensus study design, starting with stakeholder-specific questionnaire, which then extends into a multi-stakeholder engagement that involves not only technical experts, but also the broader public such as citizen experts.

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## Step 4: Delphi study material

Delphi studies often consist of questionnaires based on a desk review of the relevant literature.

Alternatively, to restrict any possible bias from pre-existing material, domain-specific customised templates could be explored.

For instance, presenting **fictive scenarios or use cases**, followed by a request to rank the use cases against feasibility and desirability, was an approach we explored in our projects. Combining this with optional text-boxes encouraged reasoning for the specific choices, added value for unearthing frictions within nascent domains like that of *in silico* medicine.

The following subsection presents a few possible formats of questions, as well as scenario-based Delphi study materials in the context of *in silico* medicine.

## Type 1: Open-ended statements on (dis)agreement

Respondents are provided with a set of statements and asked to express their agreement or disagreement using a five-point Likert scale.

The scale can range from “strongly agree” and “agree” to “neutral,” “disagree,” and “strongly disagree,” with an additional category for “no opinion”. The table on the right provides a representative set of such statements.

*Do you agree with the following statements?*



With time, <i>in silico</i> trials will entirely replace conventional trials.					
Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	No opinion

## Type 2: Free-text comments to reason responses

*Consider including a box where people can comment on answers and statements.*

## Type 3: Ranking scenarios

Presenting scenarios to which experts were asked to provide answers.

An extended list of ‘questions’ and ‘use-case scenarios’ pertaining to *in silico* medicine, for use in a typical Delphi study, is summarised in supplementary material [S1](#)  and [S2](#)  of this tool.

### Example scenario:

In the hospital, surgeons use numerical models to plan surgeries ahead of intervention. They get indications on the best shape of stent to use and its best positioning, based on a numerical reconstruction of the patient's cardiovascular system and the patient-specific data (e.g. hemodynamics etc.).

- Technical feasibility
- Viability
- Societal desirability
- Other comments?





## Step 5: Analysing responses from Delphi process

There are many possible ways to analyse data stemming from the Delphi study: **using quantitative as well as qualitative methodologies.**

Often, the most favoured opinion through consensus or percentage of votes in favour or against individual statements is reported.

Digging deeper beyond these absolute measures requires extensive qualitative analysis of the data.

Here is where social scientists play a unique role to uncover intrinsic nuances, which might otherwise be overlooked when analysing binary (dis)agreement statements.

They can eventually help to:

- document both unique and shared features/patterns;
- illustrate real and potential challenges;
- infer 'leads' or 'take-aways'.

To understand the free-text responses of the participants, qualitative research methods like Grounded Theory can prove beneficial. In practice, this entails starting with close reading of the raw text and gradually moving away from the literal text, towards identifying overarching themes.

## Example analysis framework: Value Sensitive Design

An example analysis framework that we adopted in the context of an *in silico* centric Delphi study was inspired by the **Value Sensitive Design (VSD)** and **Health Technology Assessment (HTA)** approaches, both precursors of ELSI, a well-known research framework in social science research<sup>12</sup>.

Here, the data analysis is approached in a way that allows to construct a **comprehensive understanding of the phenomenon** and identify key features as perceived by the different participating stakeholders<sup>13</sup>.

Instead of purely quantifying the answers to the Delphi questionnaire, in a technical sense, the VSD approach advocates the analytical approach, aiming to answer many intricate questions later.

For instance, it helps to probe the following questions:

- Who are the stakeholders and what are their roles, including the roles and responsibilities respondents ascribe to stakeholders (role attribution)?

- Which issues and problem definitions are presented? Which claims, and proposed solutions or recommendations, are identified?
- Which human values emerge? What is important to people in their lives with a focus on ethics and morality; e.g., wellbeing, justice, dignity.
- Which value tensions occur? Value tensions occur when values are potentially in conflict with one another, leading to trade-offs, conflicts, as well as solutions.

The aim of these exchanges is to co-construct a more holistic understanding of the phenomenon under study and identify essential and variable features as experienced by diverse stakeholders in varied contexts.

## Step 6: Input for next steps

While the objectives set out at the start of the Delphi study would be addressed by the quantitative and qualitative analysis of Delphi responses, there are often additional leads for further engagement with stakeholders.

With the novel insights and enlarged understanding, one may be able to devise guiding tools for downstream activities.

### Example outcome:

Studying the envisioned future and concerns related to the use and adoption of *in silico* technologies in medicine through a Delphi study, led to the definition of a list of public values ([see supplementary material S3](#)) for the wider *in silico* medicine community.

They serve as a valuable catalyst for discussion in subsequent focus groups (see [Tool: How to Conduct Focus Groups](#) for details).

## 2.1.4

# Final considerations

Recognising and exploring the diverse perspectives and expertise of various stakeholders enriches the process, **fostering inclusivity and enhancing the quality of insights.**





While we hope that the guidelines outlined in this Info Kit provide you with the necessary information and resources to craft a Delphi approach suited to your research objectives, it is essential to underscore the significance of multidisciplinary efforts.



## 2.1.5

# Supplementary materials

The resources stated in this handbook on focus groups can be accessed online through the link in the following Table.

Id	Type	Title of Folder/Document	Link
<b>S0</b>	Package of resources for conducting Delphi study	Consolidated zip file with all the below supplementary materials	 <a href="#">ZIP file link</a>
<b>S1</b>	Scenarios/use-cases for Delphi study	Scenarios Folder:	 <a href="#">LINK</a>
<b>S2</b>	Questions used for the Delphi study	Folder: Questionnaire for Delphi Study Languages: EN-FR-IT-NL-HU	 <a href="#">LINK</a>
<b>S3</b>	Outcome: Public values list	Folder: Public values Languages: EN-FR-IT-NL-HU	 <a href="#">LINK</a>

# 2.2

## **Tool:** **How to conduct surveys?**

**Primary target group:**  
Clinicians / Patients

**Secondary target group:**  
All stakeholders



## 2.2.1

# What is a survey?

Broadly speaking, a survey is a method of **collecting information from a certain sample of people** using a predefined list of relevant questions.

The aim of a survey is a better understanding of the chosen population(s) by capturing main **trends, perceptions and expectations**.

A survey allows describing and comparing the current state in different populations or the state in the same population across time. A correctly chosen sample allows generalising the findings from a sample to the whole population.

Surveys can take various forms, including questionnaires, interviews, or online forms. This tool will provide the necessary guidelines to design a questionnaire tailored for the *in silico* medicine domain.



## 2.2.2

### Why are surveys relevant for the *in silico* medicine community?

*In silico* medicine remains relatively nascent with strong engagement of champions across all stakeholder groups, including healthcare professionals and patients, but limited insights into the **perspectives, awareness and attitudes** of the wider population within these key stakeholder groups.

This underscores the need for a more comprehensive exploration of their perceptions and experiences in utilising Computational Modelling and Simulation (CM&S). For this reason, designing and disseminating surveys among specific target groups is a useful method to gain these valuable insights.

## 2.2.3

### Guidelines to design a survey

To successfully implement a survey, it is relevant to consider and plan a series of steps spanning from the objectives' definition up until the dissemination of the results, including fundamental preparatory work, such as ethical approval.



## Step 1: Define objectives

As for any stakeholder engagement activity, a crucial first step is to define the key objectives for conducting the survey with a certain group of participants or community.

Below are listed a few examples of survey objectives that the VPH was jointly organising for the *in silico* medicine community.

### Example 1:

Survey on the uptake of computational modelling and simulations in clinical practice. [LINK](#)

- Capture the extent of CM&S tools that are currently used, understood or accepted in the clinical community.
- Evaluate the current level of awareness and use of CM&S in clinical practice.
- Gather insights into the potential barriers and opportunities that medical professionals face when implementing these tools in their daily clinical practice.

This survey was first conducted in 2021. In 2024, a second survey with the same topic was disseminated to widen the participation and capture the change of perception on the topic over time.

### Example 2:

- To identify current Public Patient Involvement (PPI) practices and perceptions amongst the Avicenna Alliance members.
- To help raise awareness on PPI within the Avicenna Alliance by catalysing conversations about the topic.

Once you have decided on what you want to get out of the survey, you can move on to the next step: assembling a team to collaborate on the survey design.

## Step 2: Assemble team

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Designing a survey with strategically chosen and articulated questions demands significant time, effort and, very importantly, a carefully selected team of experts.

**This team should include representatives of the intended target group** as well as scientists having experience with developing, running and analysing surveys.

This will guarantee that the survey is designed in a way that is relevant for the target audience while allowing to extract a maximum of useful information.

To use the aforementioned example of the clinical surveys, these were designed in close collaboration with clinicians, modellers, social scientists and science communication experts.

## Step 3: Study design process

Following that, it is crucial to allocate sufficient time to craft **purposeful and unbiased questions**, keeping your identified objective from [step 1](#) in mind.

Consider the following factors when designing your questions:

### **Ensure the questions allow the extracting of the required data to meet objectives**

- The type of data you want to collect (quantitative vs qualitative analysis) should determine the type of questions (open vs closed questions with Likert scale).

### **Use neutral language**

- Avoid revealing objectives in the question titles; instead, use neutral numbers or letters. For instance, do not add the title “trust” for a section that questions trust levels;
- Use gender neutral language;
- Avoid suggestive words;
- Consider framing questions in a personal manner. For example, “in your opinion...”.

### **Keep the target audience in mind and be cautious with technical jargon to ensure clarity**

### **Limit the duration of the survey**

- Strive for an appropriate length to maintain participant engagement (max 10'). Inform contributors on how much time they'll need to respond.

### **Language diversity**

- Aim to offer the survey in various languages to reach a diverse audience. For example, the 2024 clinical survey is available in English, Dutch, German, French, Italian, and Spanish.

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## Step 4: Apply for ethical approval

During the survey design phase, it is crucial to proactively consider how you will utilise the outcomes, consistently keeping the defined objectives in mind.

If there is a possibility of publishing the survey results, it is imperative to seek approval from your local ethical committee before distributing the questionnaire.

This procedure can take some time, so make sure to account for this in your timeframe.

Ethical approval is recommended in all cases involving human subjects in order to **safeguard participants' rights, well-being, and confidentiality.**

## Step 5: Communication campaign

A successful survey relies on a **successful communication campaign**. As a first step, it is essential to define the various steps to reach the target group. Depending on the target and the survey goals, there are a number of different variables to consider. Nevertheless, some common aspects can guide the process, as outlined below.

### Campaign Goals:

- Encourage maximum participation in the survey;
- Highlight the importance of each individual's contribution;
- Create excitement around the topic. Define key campaign message: translate campaign goals into engaging messages.

### For example:

"Your Voice Matters: Shape the Future!".  
This is not just a slogan but a call to action.

## Campaign Elements:

1

### Official Announcement

- A formal announcement across all communication channels (website, email, newsletters, social media, etc.) introducing the survey;
- Clearly outline the purpose of the survey and its significance.

3

### Social Media

- Create engaging posts across various platforms (LinkedIn, X, Instagram, Facebook), pointing to the survey;
- Use eye-catching visuals and intriguing captions to generate curiosity and interest;
- Consider investing in a budget for paid ads.

2

### Personalised Emails

- Direct emails to the target group, emphasising the importance of their individual perspectives;
- Include a personalised message inviting them to participate and to make a difference;
- Get the collaboration of your colleagues to amplify your reach.

4

### Incentives

- Announce incentives such as gift cards, discounts, or exclusive access to scientific conferences or events. This can be practically arranged through a lottery amongst all survey participants that have consented to leave their contact information;
- Highlight the benefits of participation to encourage involvement.

5

**Peer-to-Peer Promotion**

- Encourage participants to spread the word among their personal and professional networks;
- Provide shareable and easy-to-use tools for advocacy, such as a slide deck, QR code etc.

7

**Final Push**

- A last-minute reminder across all channels, encouraging those who haven't participated yet;
- Highlight the closing date and emphasise the urgency of their input.

6

**Progress Updates**

- Regular updates on the survey's progress to keep the momentum going;
- Showcase milestones achieved and express gratitude for the participation received. This can be realised by acknowledging the survey participants through the general communication channels and news feeds through which the survey was circulated.

8

**Thank You Message**

- A heartfelt thank you message to all participants in case contact details were provided, expressing appreciation for their valuable contributions;
- Share insights on how their feedback will be used to drive positive change;
- In case the survey was fully anonymous, the thank you message can be posted on the social media channels that were used to invite participation.


## Step 6: Result's analysis

Survey analysis is a pivotal part of the study where you extract meaning from the answers provided in the questionnaire.

Beyond offering **valuable insights** and clarifying the current state of affairs, these answers can also be transformed into **new objectives** for your work.

There are a multitude of survey data analysis methods at your disposal, ranging from simple data tabulation for ease of comprehension to intricate statistical techniques that unveil hidden connections and phenomena.

Additionally, a qualitative analysis of the survey results is valuable from a social sciences point of view, because it goes beyond numerical data, providing a deeper understanding of participants' perspectives, motivations, and experiences.

The type of data to be collected and the analysis of your results are part of the design of the survey, as discussed in [step 3](#) .



## Step 7: Results' dissemination

To maximise the visibility of the key findings of your survey, it is recommended to consider multiple formats to **disseminate the results** of your survey. It is advisable to consult with your institutional communication specialist, if available, to define a proper dissemination strategy.

An important element of said strategy is mapping the profile of the audience that you would like to inform of your findings. Note that this is not necessarily the same audience as the original target of the survey. Accordingly, you may choose one of the following formats to present your results.

Researchers are reachable via scientific conferences or peer-reviewed publications. But do consider lightening up your analysis through appealing infographics (Fig. 3).



Fig. 3 graphical brochure: [LINK](#)

Stakeholder communities could be informed about survey outcomes through **position papers or landscape reports** that sketch the trends and future. In this case, language accessibility should not be a limiting factor. Therefore, domain-specific jargon can be employed.

However, a **layman language summary** can serve many purposes as it is essential for communication with the broad public and patients. In addition, it can serve as the starting point of communicating to policymakers, adding onto the summary specific barriers and opportunities in objective, clear and concise language.

All of the above-mentioned categories have different language complexity requirements and need for supplementary media, such as **pictures, infographics, videos, animations, podcasts**, etc. Be it writing short social media posts, a news article or blog posts, or making a graphical brochure to break down the message, team up with the communication expert. They can bring down the language barriers and create an engaging story tailored to the diverse groups.

Figure 4 shows an overview of the communication and dissemination material that was prepared to communicate on the 2021 clinical survey.

### Example

For the detailed results of the first clinical survey by the VPH, please refer to the following publication. [LINK](#)



Fig. 4 Infographics for social media

## Step 8: Identify next steps

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The outcomes of the survey should lead to new insights and reachable objectives, resulting in a **new action plan**.

Using the example of the 2024 clinical survey: if the survey points towards limited awareness on the subject of CM&S in a specific subgroup of the targeted group of clinicians, the survey results can provide an incentive and guidance for organising specific activities to actively engage with the clinical community or subgroups thereof, in order to **build awareness**.

Another possibility is to conduct a **longitudinal study**, where you build on the initial findings by designing follow-up rounds of the survey. By doing so, you could gain a deeper understanding of the changes over time and monitor the evolution of the field.

The results of the earlier surveys can then be used to further refine the follow-up ones to probe specific elements.

**For example**, in the 2021 clinical survey, we sensed some frictions around the 'trust' and 'barriers' for the uptake of CM&S tools in the clinic. This allowed us to refine our objective and include more specific questions, optimising each of the above steps that we outlined here.

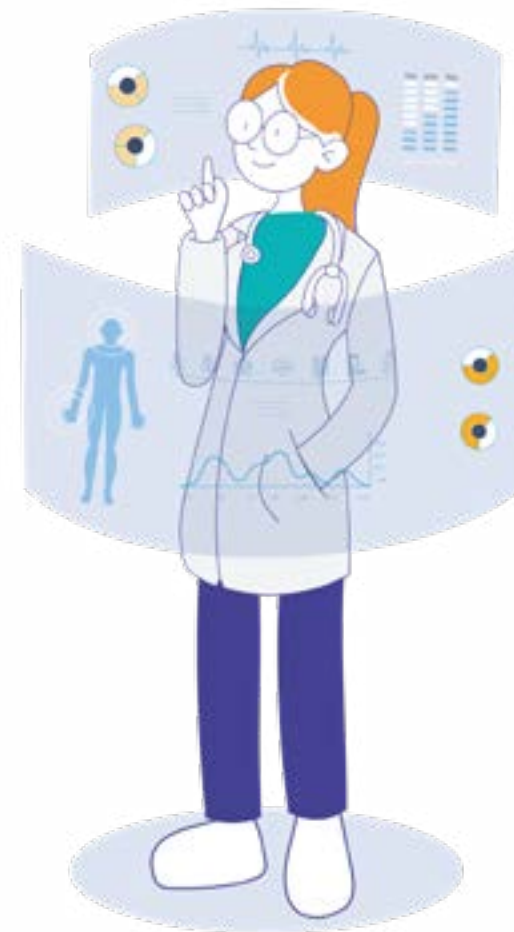
## 2.2.4

# Final considerations

Like every research method, conducting surveys has its pros and cons, which should be carefully weighed before opting for this method. **With your objective in mind, is conducting a survey an appropriate stakeholder engagement activity for you?** The following list provides some considerations to take into account while making your decision.

While surveys serve as an effective means to gain profound insights into a specific topic from a large pool of respondents, it is essential to recognise that this approach is not the sole method available. Other options exist, and thoughtful consideration is recommended when **selecting the most suitable approach for a comprehensive understanding**.

For further reading on the science behind surveys, we refer readers to the comprehensive insights on survey practices provided in 'Survey Research in the Social Sciences' and the 'Handbook of Survey Methodology for the Social Sciences'<sup>15</sup>.





## Pros

- Surveys allow participants to remain anonymous, and thus encourage honest answers. This can be very beneficial when it comes to sensitive topics;
- Surveys are a very cost- and time-efficient way to collect a lot of information from a large group of respondents, if disseminated successfully;
- Surveys collect quantitative and qualitative data, which are straightforward to analyse using statistical methods or qualitative methods, respectively;
- Surveys can cover a wide range of topics, and the researcher has a lot of freedom in designing the survey;
- Answers to questions, if designed carefully, are straightforward and not ambiguous, resulting in clear findings.



## Cons

- Surveys constrain researchers from posing supplementary questions, potentially restricting in-depth inquiry and preventing a deeper exploration of the underlying reasoning behind respondents' answers;
- Bias can occur when participants answer dishonestly, are not quite familiar or have distorted views on the subject, drop out prematurely, or are not fully attentive while answering questions;
- Bias might occur when questions are asked in a suggestive manner (e.g. asking for positive experiences without giving room for asking about negative experiences);
- Surveys might exclude a certain group of respondents, because of the digital divide or other factors (such as availability).

# 2.3

## Tool:

## How to organise a focus group?

### Primary target group:

Clinicians / Patients

### Secondary target group:

All stakeholders



## 2.3.1

# What is a focus group?

A focus group is a qualitative research method that is used to collect **opinions and feedback** from a **small group of stakeholders** who are carefully selected.

The purpose of a focus group is to gather in-depth information and insights into a particular topic, product, service, or concept by facilitating a discussion among the participants, using open-ended questions.

This method allows the **exchange of new ideas among stakeholders**, from which they can derive added value themselves.





## 2.3.2

# Why are focus groups relevant for the *in silico* medicine community?

Conducting focus groups in innovative projects can help ensure that solutions are developed with **user needs in mind**, and increase the likelihood of **successful adoption and implementation**<sup>16</sup>.

Within the context of *in silico* research projects, focus groups can provide valuable information on the societal implications of *in silico* techniques or applications, and identify possible barriers and challenges that come with the uptake of these technologies.

On top of that, they can lay out the user needs and preferences, and improve communication and engagement with and between different stakeholder groups<sup>11</sup>.

## 2.3.3

# Guidelines to design focus groups

This focus group handguide outlines the strategies, experiences, and methods that we have used in conducting focus groups within the field of *in silico* medicine. It serves as a valuable resource to guide others in planning, executing, and deriving meaningful insights from focus group discussions involving diverse stakeholders.

Keep in mind that approaching a focus group on *in silico* medicine requires careful planning, recruitment, and facilitation to ensure that the discussion is productive and informative.

Below you can find step-by-step guidelines for conducting successful focus groups. Also included are templates and ready-to-use example files, to be modified for your own use. For an extensive hands-on guide, with detailed explanations, please refer to the publication of our detailed handbook as listed in the supplementary material [SSO](#).



## Step 1: Identify research question

Before reaching out to possible stakeholders, it is important to identify the objectives of the focus group and the research questions.

### Example

#### ·Objective:

“The aim of this focus group is to discuss the perception and acceptability of *in silico* models and identify potential barriers, concerns and opportunities in order to address those issues in a responsible manner.”

#### ·Research question:

“What are the main barriers, concerns, and opportunities related to *in silico* models for the different stakeholders?”

## Step 2: Identify participants

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An ideal focus group has approximately **8 participants** (acceptable range = 6-12 persons).

This size allows for a **diversity of perspectives** while still maintaining a manageable group dynamic for effective discussion and interaction.

Having too few participants may limit the variety of opinions, while having too many may lead to difficulties in facilitating meaningful conversations and ensuring everyone's participation.

The specific context and goals of the focus group, as well as practical considerations, should also be taken into account when determining the ideal number of participants.

Based on our experience, it is advised to over-recruit when sending out invites to account for potential last-minute dropouts, ensuring better flexibility to manage a slightly larger group, rather than risking session cancellation or unsatisfactory discussions due to under-recruitment.

## Step 3: Practical elements

Based on our experience with organising focus groups, the following are some of the practical elements to plan:

### **Duration of the focus group:**

Ideally around 2-3 hours.

### **Venue:**

Accessible, private, quiet.

### **Group composition:**

Multi-stakeholder group (*in silico* experts, patient organisation representatives, policymakers, healthcare professionals, philosophers, ethical experts, general public, etc.).

Depending on the objective of the study, it can be beneficial to only include one specific group of stakeholders rather than a mix of them.

### **Outreach stages:**

(Templates available under supplementary resources)

- Initiating contact
- Preliminary emails
- Official announcements
- Formal invitations
- Final reminders
- Expressing gratitude and seeking feedback

### **Identify the need for ethical approval**

If the results of the focus group(s) will eventually be used in peer-reviewed publication(s), make sure to apply for ethical approval through your ethical committee well in time before organising the event. In any case, as the focus group involves human subjects, ethical approval is recommended to safeguard participants' rights, well-being, and confidentiality. Obtaining ethical approval might take at least a few weeks, so take this into consideration.

## Step 4:

# Focus group agenda

To ensure a smooth execution of the focus group, it is recommended to have a well-defined agenda in place, providing a structured framework for the events.

Below you can find an example agenda, similar to the one used for focus groups in Horizon2020 *in silico* medicine-related projects.

### Welcome & Introduction [10 min]

#### Phase 1: Plenary lecture format

- **Topic 1:** Introduction to *in silico* medicine in layman terms [15 min]
- **Topic 2:** Introduction to aim and course of focus group [10 min]
- **Topic 3:** Brief Q&A on set-up [15 min]

#### Phase 2: Round table discussion [1h 10min] (possible 10-min break)

- **Scenario 1:** Focus card
- **Scenario 2:** Focus card
- **Scenario 3:** Focus card

#### Phase 3: Conclusion & wrap-up [5min]

- **Topic 1:** Short conclusion
- **Topic 2:** Expressing gratitude & acknowledgements

## Step 5: Required material

Before starting the discussion, be sure to have all the documents listed below. Whereas the links point towards (mostly) English resources, it is important to foresee them in the local language spoken by the participants.

### **Informed consent:**

Make sure to have each participant sign two versions of informed consent, one for them to keep and one for the researcher. Check our template

[🔗 See supplementary material S2.](#)

### **Information sheet/flyer:**

A one-page flyer briefly summarising the 'name of the project' and 'key objectives', to situate the relevance of the focus group.

- Check our example [🔗 See supplementary material S3.](#)

### **High-level Power Point presentations on the topic, scope and aim of the study:**

- Check our Power Point examples in different languages (English, French, Dutch, Italian)

[🔗 See supplementary material S4.](#)

### **Focus cards/scenarios with illustrations:**

(Optional, in case of scenario-based discussion)

- Templates for designing scenario-based focus cards can be found here [🔗 See supplementary material S5.](#)

**List of public values pertaining *in silico* medicine:**

(Optional)

- List of guiding principles or public values to facilitate open dialogue with stakeholders [See supplementary material S6](#). This list is an outcome of a Delphi study we have conducted as a part of the In Silico World project (H2020, GA 101016503).

**Voice Recorder(s).****Refreshments and small gifts as a token of your appreciation.**

The VPH advocates the use of fictive scenarios designed by *in silico* experts to stimulate lively discussions. Ensuring accessibility for focus group participants, these scenarios are carefully written in layman's terms and supplemented with visuals collaboratively created with our graphic designers, aiming to enhance comprehension and engagement.

The following is an example of such a scenario and illustration, derived from the focus group we have organised as part of the SimCardioTest project (H2020, GA 101016496).

**TIP:**

After the focus group, make sure to thank participants for their contribution to your research. It is also advisable to send a follow-up email to the participants, allowing them to ask any questions they may still have.

## Scenario example: Digital design of a pacemaker lead

If you or a loved one suffers from arrhythmia, you may need a pacemaker.

An electrical cable (or 'pacemaker') connects your pacemaker to your heart via the veins. Its purpose is to ensure that the heart contracts at the right moment. But how can we be sure that the device is working as it should, and won't break despite the hundreds of thousands of heartbeats a day it undergoes? At present, these issues are studied through laboratory and animal testing, but this is time-consuming and costly, and raises ethical questions.

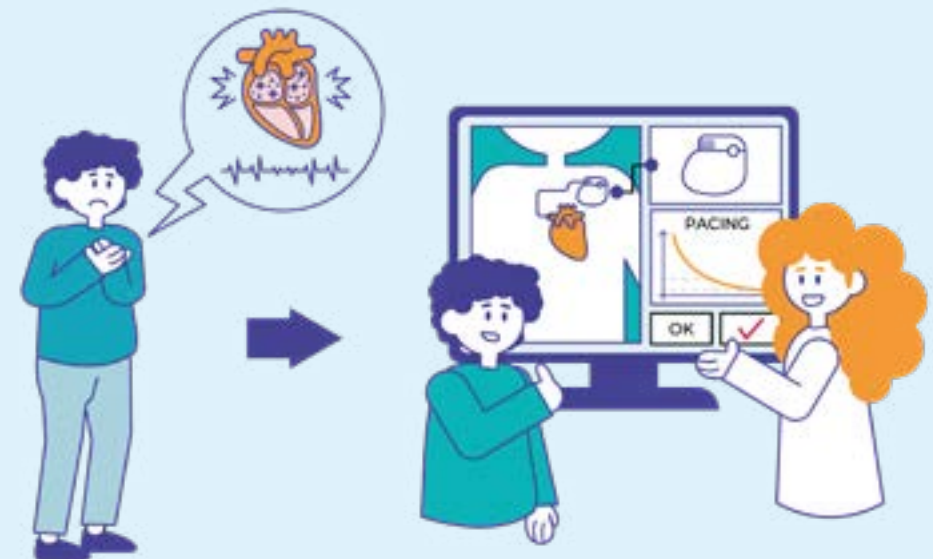
This is where digital (i.e. computer) modelling and simulations come into play.

SimCardioTest researchers are working on a 3D digital replica of a beating heart, veins and a medical device. These digital models are intended to reproduce real-life behaviour and react to simulated situations according to well-known rules of physiology and physics. We aim is to measure certain parameters accurately and rapidly by simulating hundreds of scenarios, which cannot always be easily observed in traditional clinical trials. In this way, the number of animal experiments and the number of participants in clinical trials could be reduced.

Typical questions the researchers are trying to answer are: *"How much energy do we need to deliver to the heart to trigger a heartbeat?" as this has a direct effect on battery life, or "How many heartbeats can the device's cable withstand before breaking?"*.

SimCardioTest is currently assessing the reliability and validity of the estimates that are made with the numerical model, which involves comparing simulations with experimental data to ensure that the model accurately predicts physiological processes.

(Derived from SimCardioTest project H2020-SC1-DTH-2020-1 and translated from French).



## 2.3.4

# Limitations

It is essential to note that this document is not exhaustive. We would like to underscore the need for **flexibility and adaptation to specific project requirements**, acknowledging that the provided guidelines are based on our experiences but may not cover all possible scenarios or considerations in this rapidly evolving field.













## 2.3.5

# Supplementary materials

The resources stated in this handbook on focus groups can be accessed online through the links in the following table

Id	Type	Title of Folder/Document	Link
<b>S0</b>	Package of resources for conducting focus group	Consolidated zip file with all the below supplementary materials	 <a href="#">ZIP file link</a>
<b>S1</b>	Invitation letter	Doc: Invitation emails_examples_templates_v2.	 <a href="#">Link</a>
<b>S2</b>	Informed consent & information sheets	Consent Forms and Info Sheet Languages: EN-FR-IT-NL-HU	 <a href="#">Link</a>
<b>S3</b>	Agenda	Document: agenda template	 <a href="#">Link</a>
<b>S4</b>	High-level presentation	Folder: Scientific presentation Languages: EN-FR-IT-NL	 <a href="#">Link</a>
<b>S5</b>	Scenarios/use-cases & focus cards	Document: Index of scenarios Folder: Languages: EN-FR-IT-NL-HU	 <a href="#">Link</a>
<b>S6</b>	Public values list	Folder: Public values Languages: EN-FR-IT-NL-HU	 <a href="#">Link</a>
<b>S7</b>	Transcription	Document Language: EN	 <a href="#">Link</a>

# 2.4

## Tool:

## How to conduct a reflection workshop?

### Primary target group:

Community / Consortium / Ecosystem organisation

### Secondary target group:

Regulatory / Policy / Governance stakeholders



## 2.4.1

# What is a reflection workshop?

While engagement strategies like Delphi studies, surveys, and focus groups discussed above often unearth the most pressing questions and issues, a logical next step as a research group, consortium or community, is to step back and **reflect on the learnings and observations** from these activities, to discuss ways to address them accordingly. One way to foster these reflective moments is through workshops.

A **reflection workshop**, in this case, refers to a collaborative workshop where participants are prompted to look inward and reflect on their assumptions, include other perspectives and innovate in line with these perspectives. This mode of reflexive thinking within the research community will benefit research and innovation in the long term.

The outcome of workshops may take various forms, including but not limited to a publication, a handbook or manifesto to guide ethical and socially responsible decision-making, or an improved strategy for stakeholder engagement, which could become an actionable guide for the entire community, project, institution, or consortium.



## 2.4.2

### Why are reflection workshops relevant for the *in silico* medicine community?

*In silico* medicine requires the **integration of many perspectives** in order to generate tangible benefits for patients, healthcare professionals and society at large.

Reflection workshops allow participants to open up and discuss various perspectives, needs, values and concerns, as well as to define key takeaways for practising Responsible Research and Innovation (RRI).

Other forms of engagement activities can provide the starting point for the reflection workshop and help to ensure a multifaceted perspective and discussion, even when not all stakeholders are present during the workshop.

## 2.4.3

### Guidelines to conduct a successful reflection workshop

Given that there are countless ways to organise workshops, we here present a high-level starter package without prioritising one specific style or format of a workshop.

The different steps outlined in this tool are derived from workshops in the *in silico* medicine field that were organised by the VPH, together with social science partners<sup>17</sup>, be it as part of Horizon projects or intra-university or inter-community events.



## Step 1: Define objective

The first step of any engagement activity always involves defining the objectives of the particular activity and what you ideally want to get out of it.

Here are a couple of example goals/objectives of workshops that have been conducted within several consortia of Horizon 2020 in *in silico* research projects.

### **Reflection workshop to uncover and address stakeholder needs**

#### **Objective 1:**

“Workshop to discuss the social implications of *in silico* medicine within an RRI-framework”.

#### **Objective 2:**

“Workshop to facilitate discussions on anticipatory governance with the members of the consortium”.

### **Workshop to develop an ethical manifesto for the research community**

#### **Objective:**

“The focus of this workshop is on the real-world practices of *in silico* modellers and the ethical and social responsibilities inherent to their work”.

## Step 2: Define format and structure

Truly collaborative workshops should strive for active participation of all stakeholders toward **co-creation**.

It is important to note that each workshop requires **customisation** to reach the defined objectives.

Numerous ways exist to organise workshops that facilitate open discussions and reflections on a topic.

A few examples include:

- A keynote presentation on the current-state and desired future path of a field, followed with Q&A style discussions.
- A scenario-based moderated open discussion.
- A card-based workshop, where participants react to certain statements or contexts.

In general, card-based formats structure the multi-stakeholder discussions, allowing individual priorities to be voiced.

This approach in particular aims to provide participants with a **safe platform to voice their opinions**, without pre-framing, regardless of their background or level of expertise on a topic.

In case of a large turnout, multiple groups of ideally around **6-8 people** can be formed.

Each group should include an **experienced moderator** (ideally with a social science or communication background) and an optional notetaker, to make sure the session gets recorded for analysis afterwards.

In what follows, we provide an example to organise card-based workshops, which can serve as inspiration and can be optimally tailored to your specific needs and interests.

The example pertains to a workshop that aims to prompt the consortium members to reflect on the social implications of their work, discuss different identified stakeholder perspectives, while obtaining an overview of the existing governance initiatives, and anticipate governance options within the *in silico* medicine community.

### Example 1 – Reflections on social implications & governance solutions

This example illustrates a two-hour interactive multidisciplinary workshop, as was conducted with the partners of the [In Silico World project](#). More detailed information on the course and reasoning can be found in the related publication<sup>19</sup>.

This workshop aims to report back the findings of the extensive stakeholder engagement work and is divided into two parts, each reflecting a particular aspect. The first part invites the participants to reflect on the social implications raised in previous stakeholder engagement activities (focus groups and surveys). For the second part, the participants are asked to discuss possible solutions to address and anticipate the concerns held by different stakeholders. The outputs can be drafted into tangible action points for the community, such as best practices or ethical manifestos.

To structure the open discussions, participants are presented with double-side cards that list certain 'statements' and related 'contexts', stemming from preceding focus groups with a wide array of stakeholders. The participants are asked to place the given card on a specific step within the modelling workflow (Exemplary A0 poster, Fig.5):



Figure 5:  
Workshop poster illustrating the innovation lifecycle of an in silico model, adapted from the In Silico World project and Elhadj et al.,

Duration	Agenda topic
5 minutes	Welcome
10 minutes	Introduction to the topic
5 minutes	Aims of the workshop/session layout
40 minutes	Part 1/Phase 1 of group discussions
5 minutes	Short break
40 minutes	Part 2/Phase 2 of group discussions
10 minutes	Reporting, summary & preliminary conclusions

Exemplary agenda for workshops:  
illustrative of the above examples



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## Step 3: Constitute the organising team & identify participants

Workshops like these run the risk of being perceived as webinar or dissemination events.

However, multi-disciplinary workshops engage varied levels of experience with and knowledge of a certain subject, which requires thorough consideration of how to organise the session in a way that respects and allows diverse perspectives.

### Organising team

Similar to other stakeholder engagement activities like surveys and focus groups, organising a successful workshop requires time and effort.

**Intensive multidisciplinary collaboration** between, social scientists and technical experts in the field in question is advised to prepare a successful workshop.

This could help answer questions and adjust the level of complexity accordingly.

A brief list of profiles desired for reflection workshops in the context of *in silico* medicine is the following:

**Researchers in the *in silico* medicine field**

- To promote and attend the event;
- To follow up on outcome and action points;
- To reflect on their own assumptions and hear diverse perspectives on their daily work.

**Social scientists**

- To organise, plan, conduct and analyse the event in a socially relevant way;
- To facilitate communication between stakeholder groups and to foster reflexivity;
- To participate and address social implications.

**Communication team**

- To promote the event, via different channels;
- To profile registered participants;
- To support or lead moderation.

**Supporting team**

- To take notes.

**Participants' profile**

To reflect on the objectives set out in Step 1, it is important to consciously identify the desired profile of participants that best matches the workshop goals. It is key to **identify the desired profile** and then reach out to them through dedicated channels to inform them and **encourage**

their attendance. Also, when drawing conclusions about specific stakeholder groups, it is essential to question the representation and inclusion of your engaged public.

For instance, when drawing conclusions about 'the public', it is important to **reflect on the profile and background of your participants** and how well they represent the population you are drawing conclusions about.

To reach specific stakeholder groups, consider contacting senior leadership within and across organisations, to join and also to help locate people in their network.

Through the participation of experts on the topic discussed, **the community could be inspired to change paths and explore other solutions and perspectives**. Workshops could render the community more reflexive on topics relatively new to them (e.g., social implications of their work).

**Registration process**

Ensure that the **registration process** collects basic information on the **background and expertise of all registrants**. This could help the organising team to divide the participants into desired sub-groups. The essence of a workshop relies on the active engagement of participants, which distinguishes it from a keynote lecture session or webinar, which leaves little room for open discussion.

## Grouping participants

Though it is a possibility to allow the participants to randomly join sub-groups within workshops, it is worth dedicating **effort to ensure desired voices are represented** across the different clusters of discussions.

For instance, workshops that discuss the social implications of novel technologies best include **technical and non-technical participants** from different sectors to ensure reflection and a multiplicity of perspectives.

Though it might seem straightforward, observations have shown that spontaneously formed subgroups in a workshop often lack adequate representation of one of these critical groups.

Lacking representation could undermine the efforts to deep dive.

Therefore, as an organiser, sparing time and efforts in **pre-determining the grouping of participants into sub groups**, goes a long way to facilitate quality of discussions, in line with the objectives.



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## Step 4: Materials required

Given the interactive nature of the workshops, the following provides a small list of potential materials (dependent on chosen format) useful to prepare the workshop.

### **Ethical approval & Consent form**

Ethical approval and consent forms are a must for workshops, as human subjects are involved, and publications on the findings are likely to emerge.

Therefore, apply for ethical approval through your local ethical committee well ahead of time and draft your consent forms accordingly.

**Supplementary material:** link to Template for consent form, see [🔗supplementary material S1](#).

## Cards

A deck of cards (with for example ‘statements’ or ‘illustrations’) could be derived from stakeholder engagement activities.

Subsequently, participants can deliberate about ‘agreeing/disagreeing’, ‘critical/un-important’ or ‘positioning or ranking it within a workflow’ to structure the discussion.

Two-sided cards can contain general questions on the one side and more detailed statements or contexts on the other side to deepen discussions.

[🔗Supplementary material S2](#): example of statement cards.

### Theme & statement 1

#### (Front)

How can you ensure the quality of the parameters in the model?

#### (Back)

“We give answers to the questions that we ask. But what if a crucial parameter is neglected, and we do not know about it?”

### Theme & statement 2

#### (Front)

Could the reduction to animal testing through *in silico* trials be a reality?

Replace or support?

#### (Back)

“This is the ethical way. We can only trust *in silico* data if they match or agree well with *in vivo* data. I would not approve anything without *in vivo* data. We don’t have all the parameters. The *in vivo* configurations are way more complex than we have thought”.

## Poster/white board/e-white-board

Posters, whiteboards or electronic boards could be used to anchor 'statements' to a certain workflow or category. Few examples of electronic discussion boards are [Miro](#), [Wooclap](#), and [Mentimeter](#). When using online solutions, it is important to foresee that participants have access to the internet and the corresponding session code or QR code to the electronic discussion boards.

**Supplementary material to facilitate discussion:** In the scope of the first example mentioned above, participants were asked to place cards on the modelling workflow. An A0 formatted poster (see [supplementary material S4](#)) illustrating the lifecycle of an *in silico* model was created in close collaboration with experts in the field, to allow the visual mapping of specific topics to their relevant stages.

## Stationery and extra materials to provide

- **Pens, markers and/or electronic tools** to access poster/e-boards.
- **Notepads:** for participants to take notes or organise their thoughts for the discussion.
- **Sticker dots:** to indicate priority, ranking, and preference grouping.
- **Post-its:** to allow extra remarks, beyond just ranking or indication of preference.

## Handbook with script of workshop

Leading up to the workshop, a detailed workshop guide could be prepared to inform organisers, moderators and notetakers of the course of the event.

Such material is instrumental in aligning the organising team on their expected roles, as well as providing lists of possible questions to steer discussions in the desired manner across the group.

**Supplementary material:** An example of such a handbook is provided as a [supplementary material S4](#).



## Step 5: Workshop set up

The setup of a workshop venue is crucial for **fostering interaction and engagement**, so careful attention to seating arrangements, audio clarity, and group spacing is essential to avoid a lecture-style setup and **encourage roundtable discussions**. For multiple small group discussions, ensure the room is spacious enough so that voice recorders can capture the audio clearly, without interference.

### A. Audio-visual presentation tools

Presentations can be useful to introduce the topic, objective, and agenda of the discussion. It can also be useful to wrap up the workshop with a short presentation of the outcomes of the different groups.

If you would consider remote participants for workshops, ensure that the moderator engages online participants and ensure the presence of appropriate audio/video and network facilities in the venue to ensure that the online participants can follow everything and their voices are adequately captured.

### B. Recording devices

To report on the workshop, or more importantly, to conduct an in-depth qualitative analysis of the pseudo-anonimised transcripts, consider using dedicated voice recorders.

Note that the recording of the workshop should be explicitly mentioned ahead of time and be stated in the consent forms.

## Step 6:

# Workshop conduction & moderation

In its simplest form, workshops are perceived as small group discussions, oftentimes entailing a hands-on element. Naturally, different topics are touched upon during the organic group discussions.

The role of the moderator is multiple: creating a safe and comfortable space for the participants to voice opinions and making sure each participant shares their perspectives equally, as well as keeping the discussions in line with the defined objectives whilst allowing deviation from the guiding moderator script in certain cases.

After a round of introductions, where participants get to know each other and the moderator explains the course in detail, the discussion rounds can commence.

### Key considerations:

#### Avoid keynotes that end up in monologues

- Introduce a professional moderator to encourage dialogue and engagement of participants.

#### Stimulate active participation of attendees, by engaging them

- By opening polls and questions during the session;
- Seeking opinion on provoking statements.

#### Limit dialogue where only a couple of dominant voices participate

- Avoiding losing the interest of the rest of your participants, for the remainder of the session.

#### Be watchful of scope and time

- Note-taker can support moderator and act as a supporting voice to streamline discussions to remain in the scope.

#### Summarise very briefly your key discussions for the whole group



## Step 7: Post-workshop analysis

After the workshop, transcripts and notes should be analysed using qualitative methods and coding tools like Atlas.ti, enabling social scientists to systematically **identify themes, sub-themes, and key insights**.

Collecting all notes and recordings allows for a structured analysis that reveals key findings and aligns with the workshop's objectives.

It is good practice to share some form of meeting minutes with the participants, especially when reflection workshops are hosted in the context of collaborative projects.

## Step 8: Workshop's outcomes

Just like there are numerous ways to organise workshops, there are numerous outcomes possible.

Multidisciplinary workshops on a topic like *in silico* medicine could inform policy guidelines, governance of digital health innovations, research and innovation plans, ethical manifestos for the research community, and strategies to engage stakeholders, etc.






These could be relevant for the individual researchers, research groups or institutions, publicly-funded R&I projects or sectoral organisations (industry, academia, non-governmental) within the *in silico* landscape.

More importantly, reflection workshops and their outcomes should be a **living process that continues to evolve** in order to best meet the latest innovation landscape of the healthcare sector.

## 2.4.4

# Supplementary Materials

The resources stated in this handbook on theworkshop can be accessed online through the links in the following table.

Id	Type	Title of Folder/Document	Link
<b>S0</b>	Package of resources for conducting focus group	Consolidated zip file with all the below supplementary materials	 <a href="#">ZIP file link</a>
<b>S1</b>	Informed Consent & information sheets	Folder: Consent Forms and Info Sheet Languages: EN	 <a href="#">Link</a>
<b>S2</b>	Statement cards	Folder: Consent Forms and Info Sheet Languages: EN	 <a href="#">Link</a>
<b>S3</b>	Modelling workflow	Folder: Scientific presentation Languages: EN-FR-IT-NL	 <a href="#">Link</a>
<b>S4</b>	Handbook	Document	 <a href="#">Link</a>



# 3.0

## Resources on *in silico* medicine

In this second part of the Info Kit, a set of resources is presented that are useful in engaging with the different stakeholders. The first section discusses glossaries to help define *in silico*-related terminologies to different stakeholder groups. The subsequent section presents a curated list of ready-to-use multimedia resources, including information videos, presentations, podcasts, etc. The readers may find these resources handy, especially

when targeting lay audiences, who may have never heard or been familiar with the term *in silico* medicine. We welcome anyone to use these resources and share them with interested parties. The examples provided are a non-exhaustive list intended to illustrate the different types of resources. The VPH welcomes additional examples that can be shared with the community through a link on the VPH website.

# 3.1

## Resource: Glossary of *in silico* terminology

Glossaries are lists of terms designed to educate a community, fostering clarity and addressing definitional challenges, thereby enhancing awareness and understanding among stakeholders.

### Primary target group:

Technology developers / Clinicians /  
Key Opinion Leaders

### Secondary target group:

All stakeholders



### 3.1.1

## Why are glossaries relevant for *in silico* medicine?

*In silico* medicine is going through fast development, and so are all the technologies behind it.

In this fast-changing environment, developing a **common and understandable language** is key to ensure effective and efficient communication between all stakeholders.

Including a glossary of terms in all related publications is necessary to **allow clear communication and enable co-creation** with the involvement of all stakeholders, including scientists, healthcare professionals, companies, policymakers, and patients.

Building and maintaining a commonly shared glossary is an important activity and requires a continuous effort from the community.

Based on this standard glossary, additional glossaries can be defined for specific stakeholders, translating technical definitions into accessible language focused on explaining the concept in broad terms.



## 3.1.2

# When and how to draft glossaries?

In literature on *in silico* medicine, including peer-reviewed articles, review papers, industry reports, or vision documents, occasionally there are different interpretations of *in silico* medicine terms and concepts, possibly leading to misunderstandings.

This becomes especially problematic when dealing with stakeholders from regulatory and policy backgrounds, where these misunderstandings might have repercussions for the **acceptance and uptake of *in silico* medicine solutions**.

Several scientific publications and white papers written by authors representing multiple stakeholders<sup>20,21</sup>, have started including a section on terminology to lay a common ground for both the readers and the authors.

This often requires the computational modelling and simulation community to break down the *in silico* jargon for non-domain readers. In addition, while setting out the key issues or solutions of *in silico* medicine, there is often also a need to acknowledge the difference in definitions or the presence of multiple definitions, subject to the community that uses it or the way the technology is used.

Here is where glossaries become an indispensable component of publications, including position papers.

They set out the relevant definitions of the terminology used in the paper. Such definitions are useful to clarify terms and concepts which may not be explicitly defined or explained in the body of a position paper.

To provide the community with **clarity on definitions**, a team of members from academia and industry (VPH and Avicenna Alliance), regularly collate a list of words and *in silico*-related terms.

Through consensus, the meaning of commonly used terms are clarified, for use in our publications. For instance, the Avicenna Alliance has produced a third release (August 2023) of its [Living glossary of computational modelling and simulation terms](#).

The glossary contains the main definitions for the terminology found in this Info Kit and may also help learn more about *in silico* medicine.



The *in silico* medicine community is encouraged to adopt the proposed terminology and definitions in their work, including internal documents, research publications, project proposals to national and international funding agencies, project deliverables and consortium outreach activities, and review articles or position papers.

This would go a long way to not only promote harmony in the definitions, but also help other communities and stakeholders to approach and **better understand the *in silico* medicine domain**, thus paving the way to minimise misinterpretations and frictions.

Finally, creating glossaries is a **community-driven effort**, welcoming the participation of all interested people from the entire ecosystem, to suggest new terminologies to be included in the existing glossaries and/or to share feedback to refine the current definitions.



## Examples

Title	Description	Stakeholders involved	Intended stakeholders
Avicenna Alliance Glossary of terms for computer modelling and simulation <a href="#">LINK</a>	Technical glossary of <i>in silico</i> medicine-related terms	Academia, industry	All
<a href="#">The Role of Artificial Intelligence within In Silico Medicine</a>	White paper describing the <i>in silico</i> medicine technology spectrum, the position of AI on the spectrum and the interaction between AI and knowledge-based <i>in silico</i> medicine technologies	Academia, industry	Policymakers
The Avicenna Alliance PPI position paper <a href="#">LINK</a>	Position paper describing the Public & Patient Involvement landscape. Includes definitions on “Patient experts”, “Patient advocates”, by collating observations in literature and those recommended by pioneering patient advocacy organisations like that of European Patients’ Academy on Therapeutic Innovation (EUPATI) <a href="#">LINK</a>	Academia, industry	Lay audience, patients and patient organisations
Scientific and regulatory evaluation of mechanistic <i>in silico</i> drug and disease models in drug development: Building model credibility <sup>22</sup>	A white paper resulting from a series of workshops and meetings between various stakeholders related to modelling & simulation in drug development. Guidelines for assessing model credibility in a regulatory context <a href="#">LINK</a>	Academia, industry, regulators, HTA	Academia, industry, regulators, HTA

# 3.2

## Resource: Multimedia

The subsequent section presents a curated list of ready-to-use multimedia resources, including information videos, presentations, podcasts, etc. The readers may find these resources handy, especially when targeting lay audiences, who may have never heard or been familiar with the term *in silico* medicine.

### **Primary target group:**

Technology developers / Clinicians /  
Key Opinion Leaders

### **Secondary target group:**

All stakeholders



## 3.2.1

# Informative videos

To promote greater recognition and popularisation of *in silico* medicine outside academic and clinical institutions, several videos have been created in recent years by the community.

These videos, primarily targeting lay audiences, serve as a helpful introduction to *in silico* medicine, as well as updates on its latest trends and applications.

### Individual videos on *in silico* medicine

The following are a few examples of the publicly available videos on *in silico* medicine.

Moreover, the VPH continues to collect similar *in silico* medicine related videos in a specific playlist hosted on its YouTube channel: [LINK](#).



## DIGITAL TWINS: The Journey Towards Better Healthcare

(1 min 47 sec) Produced by the VPH

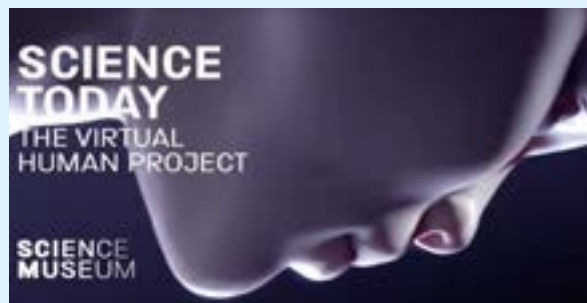


What is a Digital Twin? How can it be used to make our life better? In this short video, the VPH explains in very simple terms how through the use of computer simulations we can create digital versions of ourselves (Digital Twins) to improve the understanding, prevention, diagnosis and treatment of a disease.

[!\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\) LINK](#)

## VIRTUAL HUMAN

(6 min 20 sec) Produced by Barcelona Supercomputing Centre and CompBioMed H2020 Centre of Excellence in Computational Biomedicine, led by the University College of London



The Virtual Human project has the potential to transform medicine. The project is already helping to reduce the need for animals in drug testing. In the long term, a virtual version of you will be used to test treatments, like a crash test dummy, guinea pig and trial volunteer all rolled into one.

Your digital doppelgänger could breathe, blister and bleed. It could be dissected, probed and explored in unprecedented detail, helping to work out the treatments that work best for you.

[!\[\]\(6bb0e4f14c4133b37d2887cb37e67ddd\_img.jpg\) LINK](#)

## IS THIS THE FUTURE OF HEALTH?

(3 min 37 sec) Produced by The Economist



Artificial intelligence is already shaping the world, from driverless cars to dating.

But according to Dr Eric Topol, a pioneer in digital medicine, perhaps its greatest impact will be on people's health.

[!\[\]\(7bc43b319a082987e20f7bf78f4bab80\_img.jpg\) LINK](#)

## Video series on *in silico* medicine

In order to better explain the various facets of *in silico* medicine in a coherent and accessible manner, a series of videos can sometimes be more efficient than one longer video.

To this end, the VPH produced a series of animated videos covering a range of topics related to *in silico* medicine, starting with a general overview, followed by explanations of different modelling technologies, *in silico* trials, applications in clinical practice, along with discussions on trust and ethical issues.

These videos can be accessed in a dedicated playlist here: [🔗VPH-Animated-Video-Series-Playlist.](#)

### EPISODE 1 UNDERSTANDING IN SILICO MEDICINE

(15/02/2024) 1 min 26 sec

What is the next big thing in healthcare? *In silico* medicine, of course. But what is it? Let's discover it together with the series 'Code & Cure': Understanding In Silico Medicine". This first video explains in a very simple way the concept of *in silico* medicine and what it can do for all of us. [🔗LINK](#)



### EPISODE 2 WHAT IS A COMPUTER MODEL?

(21/03/2024) 1 min 27 sec

You might not notice it, but computer models are everywhere around us, from your smartphone calculating the fastest route to work to the aerodynamic simulations of cars and planes. In this video, we will discover how we can make the most of them for better healthcare. [🔗LINK](#)



### EPISODE 3 ARTIFICIAL INTELLIGENCE IN HEALTHCARE

(03/06/2024) 1 min 7 sec

As an *in silico* medicine tool, Artificial Intelligence plays an important role in many aspects of medical clinics. In this video, we will show how, thanks to AI, we can turn all the data surrounding us into actionable medical decisions. [LINK](#)



### EPISODE 5 IN SILICO TRIALS

(30/09/2024) 1 min 41 sec

*In silico* trials, using virtual populations based on real patients, streamline drug and device development by reducing reliance on animal and human testing. They cut costs, accelerate innovation, and enhance patient access, fostering collaboration across stakeholders. [LINK](#)



### EPISODE 4 TECHNOLOGIES BEHIND IN SILICO MEDICINE

(31/07/2024) 1 min 27 sec

*In silico* medicine would not be possible without many supporting technologies. The fourth video of the series Code & Cure will present how medical imaging, supercomputers, and virtual and augmented reality (AR/VR) contribute to it. [LINK](#)



### EPISODE 6 MEDICAL DATA- SAFETY & PRIVACY

(30/10/2024) 1 min 34 sec

Medical data are a fundamental asset of *in silico* medicine. They may include age, gender, genetic information, medical history, and more. Protecting the safety and privacy of these sensitive data is crucial, while ensuring accessibility is also key. [LINK](#)





## EPISODE 7 IN SILICO MEDICINE- REVOLUTIONISING MUSCULOSKELETAL CARE

(19/12/2024) 1:42

Many bone and muscle conditions are linked to illness or aging. Discover how *in silico* medicine is transforming the diagnosis, prevention, and treatment of musculoskeletal disorders—improving lives worldwide. [LINK](#)



## EPISODE 9 BEATING CHILDHOOD CANCER WITH IN SILICO MEDICINE

(30/04/2025) 1:44

Childhood cancer is devastating for patients, families, and doctors. Discover how *in silico* models can predict tumour response to chemo, helping tailor safer, more effective treatments. [LINK](#)



## EPISODE 8 DIGITAL HEARTS - THE FUTURE OF CARDIOVASCULAR MEDICINE

(27/03/2025) 1:47

Heart diseases are the leading cause of death worldwide. Discover how *in silico* medicine helps clinicians virtually test devices like pacemakers and occluders—improving selection, surgical precision, and patient outcomes. [LINK](#)



## EPISODE 10 WITH GREAT POWER COMES GREAT RESPONSIBILITY

(30/05/2025) 1:31

*In silico* medicine is reshaping healthcare, but innovation needs transparency, inclusivity, and collaboration. Discover how experts and patients are co-creating a future healthcare that's equitable, trustworthy, and built for everyone. [LINK](#)





## 3.2.2

# Podcast

Podcasts are a powerful instrument that, in many ways, is changing communication. Given the relative novelty of this communication medium, many formats are still to be explored.

Differently from radio shows, podcasts are **thematic** and **on-demand**.

The audience can decide the topic they want, and listen to it wherever and whenever they prefer.

Moreover, unlike television and videos, listening to a podcast is an activity that can be combined with others, such as running, driving, or doing domestic duties. It also explains why most podcasts are between **10 and 30 minutes in length**, which corresponds to the average home-to-work commute.

Another significant difference is from the producer side. Again, unlike videos, podcasts do not require advanced skills and complex and expensive equipment.

A mobile phone has enough power and features to record, edit, and publish a podcast.

Since April 2024, the VPH has been producing a podcast series dedicated to *in silico* medicine, titled **“The Digital Twin Theory”**.

This podcast aims to **inform and involve a lay audience** of science enthusiasts and patients interested *in silico* medicine.

This is also reflected in the choice of the title, which takes inspiration from the TV show “The Big Bang Theory”, which popularised the figure of the scientist and made accessible and fun topics that were perceived as complex and inaccessible.

Each episode of the podcast includes an engaging and accessible discussion about an *in silico* medicine topic with young scientists, experienced professors, doctors, policymakers, social scientists, philosophers, patients and more.

After the release of The Digital Twin Theory, the authors also acknowledge the podcast [🔗 \*In Silico\* Trials, Real Impacts](#), launched in September 2024 by the [🔗 InSilicoUK Pro Innovation Regulations Network](#), with a specific focus on *in silico* trials.

Apart from the abovementioned podcasts, which are fully dedicated to the *in silico* medicine field or one of its sub-fields, there is also a high number of single episodes from generalistic podcasts on medicine, science, and technology that also focus on *in silico* medicine.

The following is a list of the episodes of The Digital Twin Theory podcast published at the time of the release of this document.

## EPISODE 1 INTRODUCTION TO IN SILICO MEDICINE

(02/04/2024)

Is *In silico* medicine the future of healthcare? And what can it do for us? To know more, we interviewed **Liesbet Geris**, professor of Biomechanics and Computational Tissue Engineering at ULiege and KU Leuven, and Executive Director of VPH - The Society for In Silico Medicine.

[🔗 Youtube](#) | [🔗 Spotify](#)



## EPISODE 2 HOW MODELS WORK

(03/05/2024)

What is a computer model? How can we build one? How can they be used to improve healthcare? We asked all such questions to **Himanshu Kaul**, Royal Academy of Engineering Research Fellow and Principal Investigator at the Laboratory for Multiscale Emergent Bioengineering at the University of Leicester

[🔗 Youtube](#) | [🔗 Spotify](#)



### EPISODE 3 THE POWER OF AI IN MEDICINE

(30/05/2024)

AI is transforming healthcare, enhancing efficiency and innovation. When did this revolution begin, and how can it benefit doctors globally? We discussed this with **Leonardo Castorina**, a PhD student at the University of Edinburgh, specialising in AI-driven protein design and immunology.

[🔗 Youtube](#) | [🔗 Spotify](#)



### EPISODE 5 PROTECTING PRIVACY IN THE AGE OF DATA

(26/09/2024)

Data is the cornerstone of *in silico* medicine. In this episode, we explore how managing medical data effectively is key to making it a reality. Our guest, **Elisabetta Biasin**, a doctoral researcher at KU Leuven's Centre for IT and IP Law, shares her insights.

[🔗 Youtube](#) | [🔗 Spotify](#)



### EPISODE 4 VIRTUAL PATIENTS

(28/06/2024)

Drug development takes 10-15 years and costs millions, most spent on clinical trials to ensure safety and efficacy. This process can be made faster, cheaper and safer.

**Francesco Pappalardo**, Computer Science Professor at the University of Catania shares his insights on *in silico* trials.

[🔗 Youtube](#) | [🔗 Spotify](#)



### EPISODE 6 ETHICS AND THE VIRTUAL HUMAN TWIN

(05/11/2024)

*In silico* medicine revolutionises healthcare but raises ethical concerns like data management, tech access, and doctor-patient dynamics. **Michele Barbier**, ethics expert for the European Commission and EU project coordinator at INRIA, shares insights on its challenges and potential.

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### 3.2.3

## Presentations

While engaging with patients or members of the general public, it is important to ensure that the concept of *in silico* medicine is explained in layman's terms, making it **accessible and understandable**.

Therefore, a technical, but understandable presentation at the start of the stakeholder engagement activity (e.g. focus group), is often necessary.

The [🔗Supplementary material S4](#) offers a good example of such a presentation in multiple languages (EN-IT-FR-NL-DE).



# 3.3

## Resource: Case studies

Case studies provide tangible examples of technological advancements in real-world contexts of use: device development & testing, clinical trials, regulatory evaluation or clinical decision making.

Case studies provide a concise yet structured format to highlight the value of health technologies by clearly demonstrating how innovations address unmet needs, supported by references to peer-reviewed publications for further reading.

This section presents two representative case studies. In each case, the descriptions start from an unmet (clinical) need, before moving into the *in silico* medicine methodology, and finally ending with a brief note on the (clinical) application of the in silico technology.

### **Primary target group:**

Technology developers / Clinicians /  
Key Opinion Leaders

### **Secondary target group:**

All stakeholders



## Case study 1

# Predicting bone fracture risk with BoneStrength

### Clinical need/challenge

Investigate the efficacy of antiresorptive drugs, a class of drugs aimed at treating osteoporosis and preventing fragility bone fractures.

- **Product Type:** Drug
- **Category:** Musculoskeletal/orthopaedics
- **Disease:** Osteoporosis/bone fracture

### In silico method

At the core of BoneStrength, there is Biomechanical Computed Tomography (BCT), a Digital Twin pipeline that allows patient-specific femur fracture risk estimation starting from a femur CT scan and a few other personal data (such as height and weight).

### In silico trial solution

Simulate a phase III clinical trial by creating a large number of virtual patients (~1000), estimating their bone ageing with and without pharmacological treatments over several years, and evaluating patient fracture risk in different scenarios.

### Current state: regulatory evidence

- Viceconti, M., Curreli, C., Aldieri, A., & Pappalardo, F. (2024). "BBCT-Hip Qualification advice with EMA - Public Domain Documents (Version v1)". Zenodo. [LINK](#).
- Clinical Validation of BBCT-hip (ValidaBBCT-hip) [LINK](#)

### Additional materials

- Aldieri, A., Curreli, C., Szyszko, J. A., La Mattina, A. A. & Viceconti, M. Credibility assessment of computational models according to ASME V&V40: Application to the Bologna biomechanical computed tomography solution. Comput. Methods Programs Biomed. 240, 107727 [LINK](#).
- Aldieri, A., Terzini, M., Audenino, A.L. et al. "Personalised 3D Assessment of Trochanteric Soft Tissues Improves HIP Fracture Classification Accuracy". Ann Biomed Eng 50, 303–313 (2022) [LINK](#).



## Case study 2

# Modelling for tuberculosis vaccine development

### Clinical need/challenge

Predict the outcome of new vaccination strategies for active tuberculosis.

- **Product Type:** Drug
- **Category:** Vaccine/infectious disease
- **Disease:** Tuberculosis

### In silico method

The Universal Immune System Simulator – Tuberculosis (UISS-TB) is a simulator of the immune system dynamics, particularly tailored to predict the response of the human immune system to exposure to *Mycobacterium tuberculosis*.

### In silico trial solution

*In silico* lab solution to predict the outcome of new vaccination strategies. Validated with data coming from clinical trials of two vaccines (RUTI and ID93+GLA-SE).

### Current state: regulatory evidence

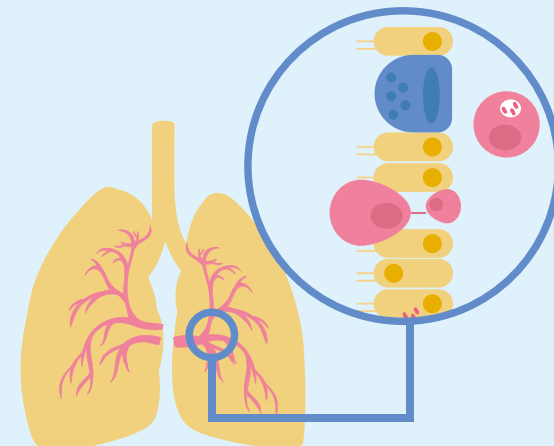
Letter of support on the qualification of the methodology, based on validation using anonymized data coming from patients enrolled in the STriTuVaD EC-funded project.

- Pappalardo, F., Viceconti, M., Curreli, C., & Russo, G. (2024). UISS-TB Qualification advice with EMA - Public Domain Documents (Version v1). Zenodo. [🔗\(LINK\)](#)

- Pappalardo, F., Russo, G., Di Salvatore, V., Battiato, S., Guarnera, F., & Rondinella, A. (2024). MSValid Data Collection [Data set]. Zenodo. [🔗\(LINK\)](#)

### Additional materials

- Maleki A., Crispino E., Italia S.A., Di Salvatore V., Chiacchio M.A., Sips F., Bursi R., Russo G., Maimone D., Pappalardo F. (2023). Moving forward through the *in silico* modeling of multiple sclerosis: Treatment layer implementation and validation. Comput Struct Biotechnol J. 21:3081-3090. [🔗LINK](#). PMID: 37266405; PMCID: PMC10230825.
- [🔗In Silico World: Fighting the Tuberculosis with UISS-TB](#)





# 3.4

## Resource: Success Stories

Success stories are a powerful tool for communicating and engaging with different audiences, especially non-specialised ones. They allow to showcase real-life applications of *in silico* technologies, helping to promote *in silico* medicine among clinicians, patients, and policymakers. Moreover, the storytelling format, by focusing on a specific case enables a deeper, emotionally resonant connection with the narrative. This approach can effectively highlight advancements in *in silico* medicine, engage and inform stakeholders, stimulate discussions, and attract potential collaborations.

### **Primary target group:**

Technology developers / Clinicians /  
Key Opinion Leaders

### **Secondary target group:**

All stakeholders





## 3.4.1

# How to draft a success story?

Many are the formats that can be adopted for storytelling. A potential structure for a success story could include the following elements:

### 1. Hook

Introduce the story with a few lines setting the tone, such as identifying the health condition at the centre of the story.

### 2. Problem

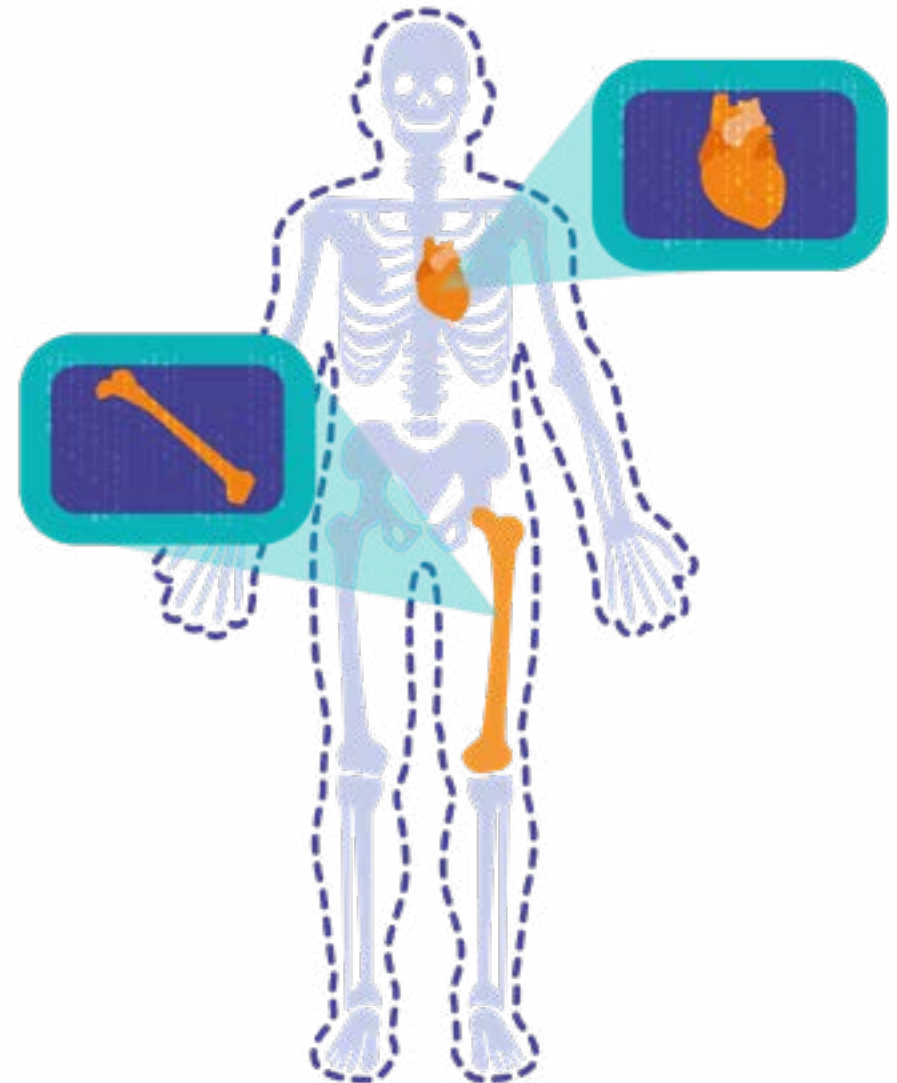
Present the condition in more detail with facts and figures, explaining why addressing this issue is important.

### 3. Solution

Explain the *in silico* solution, detailing how it improves the lives of the target audience, whether clinicians, policymakers, or patients.

### 4. Conclusion

Look ahead, discussing how this technology or procedure could further improve healthcare in the future.



## Identifying a success story in the context of *in silico* medicine

Choosing the right topic is key, though it can be challenging. Ideally, success stories would focus on patient outcomes, but examples of bedside applications of *in silico* medicine are still limited. A viable alternative is to focus on clinical trials, which broadens the range of available success stories. This approach also provides an opportunity to explain how clinical trials work and the drug approval process. Even when a drug is ultimately rejected, it can still be framed as a success for public health, showing that science is a process of learning, including through failures that contribute to eventual success.

## Tailoring it for a specific audience

It is crucial to tailor the story to the specific target audience:

- **For clinicians**, a success story could focus on how *in silico* technology made their work more efficient or improved patient outcomes;
- **For policymakers**, it might highlight how public health could be enhanced by adopting certain initiatives;
- **For patients**, the focus should be on how *in silico* technologies improve their quality of life, enhance treatment outcomes, or reduce side effects.

## Details vs impact

Unlike scholarly publications, success stories should not focus on the scientific and technical details. Instead, they should emphasise the **impact on people and processes**. For example, rather than explaining the intricacies of a new computer model, success stories highlight how it can help clinicians perform better, enable policymakers to achieve health goals, or improve patients' lives. Writing from the perspective of the target audience, such as a specific doctor, patient, or hospital, also naming people and hospitals, whenever possible, can make the story more relatable and engaging.

## Virtual Reality in Healthcare- A success story

(#AR/VR)

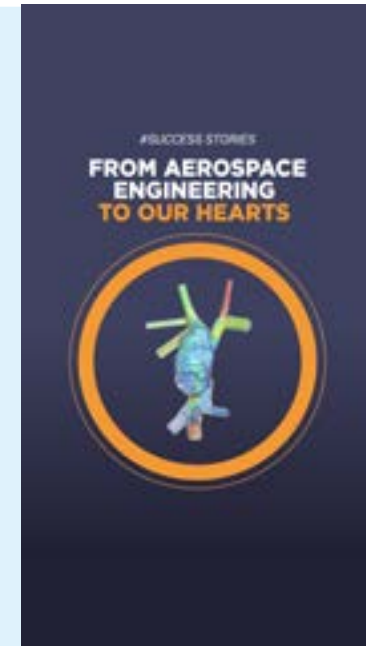
The entertainment industry popularised Virtual and Augmented Reality, but now, they're providing a valuable contribution to healthcare, from university classrooms to the operating theatre. In this mini-review, you'll find notable examples of the application of Virtual and Augmented Reality in different contexts. [LINK](#)



## From aerospace engineering to our hearts

(#cardiology)

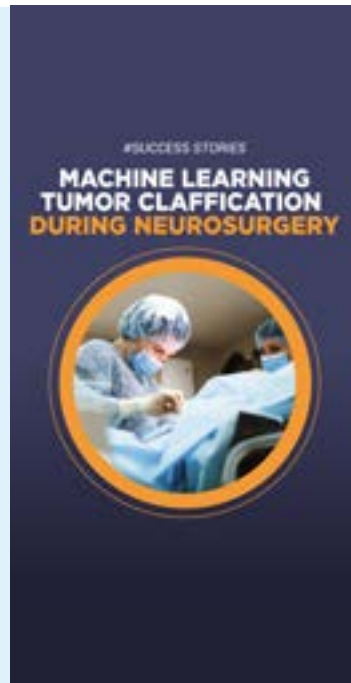
Surgeons from the Boston Children's Hospital Center collaborated with an engineering company to design a cardiac patch and plan surgery for an 18-year-old patient with a complex cardiac condition. [LINK](#)



## Machine learning approach allows for tumour classification during neurosurgery

(#machinelearning, #cancer)

Meet Sturgeon, a neural network classifier which is able to provide a classification for Central Nervous System Tumours during the surgery itself, providing fundamental information for the surgeon on how to proceed. [LINK](#)



## A new era for tuberculosis vaccines is coming

(#vaccines)

Meet UISS-TB, a simulation framework to model the interaction between the immune system, the bacteria causing tuberculosis, and a vaccine. [LINK](#)



## In silico trial predicts phase 3 clinical trial result

(#clinicaltrials)

Dr. Duruisseaux from the Hospice Civil de Lyon (France) replicated a three-year long phase 3 trial with an *in silico* trial executed on 5000 virtual patients, in a few weeks. The results of the *in silico* trial closely resembled the ones from the traditional clinical trial, albeit at a fraction of the time and cost.

[LINK](#)



## Enhancing Clinical Decision-Making: The Role of CDSS in Modern Healthcare

(#diagnosis)

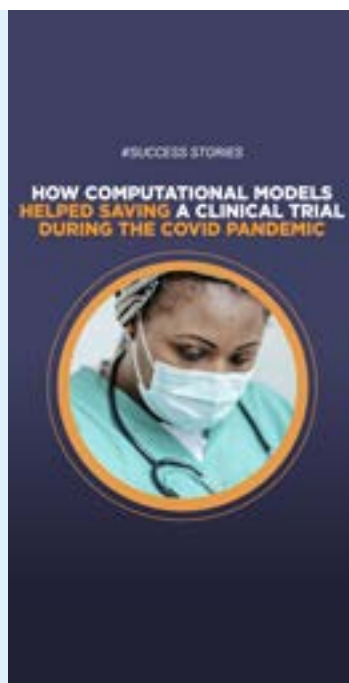
Clinicians face critical decisions daily. Clinical Decision Support Systems (CDSS) integrate patient data with medical knowledge, offering evidence-based recommendations. At Mayo Clinic, CDSS, enhances treatment plans, reducing unnecessary procedures, and allowing doctors more time with patients. [LINK](#)



## How computational models helped saving a clinical trial during the COVID pandemic

(#clinicaltrials)

The COVID pandemic disrupted clinical studies globally, including those assessing Ritlecitinib's safety in hepatic and renal impairments. Hindered by recruitment challenges, scientists employed a computer model to create virtual populations based on previous studies, facilitating the continuation of the clinical trial, during the pandemic. [LINK](#)



## Speeding up Duchenne Muscular Dystrophy therapies with a model-based clinical trial simulator

(#clinicaltrials)

Enzo Ferrari's son, Dino, was diagnosed with Duchenne Muscular Dystrophy (DMD), a severe genetic disorder affecting muscles and leading to progressive weakness and early death. Advances in DMD research led to the creation of a clinical trial simulation tool by C-Path's to aid drug development and regulatory approval. [LINK](#)



# 3.5

## Resource: Position papers, landscape reports, white papers

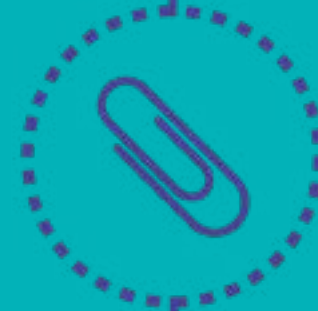
Community-driven position papers, in which the current position, outlook and key challenges of the *in silico* medicine community are presented, are a good way for certain stakeholders to provide content in an accessible manner, providing more discussion and detail than is possible in other resources.

### Primary target group:

Technology developers / Clinicians /  
Key Opinion Leaders

### Secondary target group:

All stakeholders





## 3.5.1

# Position papers about *in silico* medicine

The VPH actively collaborates with the Avicenna Alliance on a number of advocacy activities and frequently releases position papers, landscape reports and white papers as a first step in advocacy work to set the scene from the angle of a particular stakeholder's interests.

Listing the exhaustive library of position papers pertaining to the domain is outside the scope of this document. Instead, a short list is provided below, referring to position papers on *in silico* trial technologies that are of immediate relevance to the modelling community and healthcare professionals.

The list is curated for the quick read of beginners, who are on the journey of familiarising themselves with the domain of *in silico* medicine technologies.

- **2016:** Avicenna Alliance Roadmap: Viceconti, Marco & Henney, Adriano & Morley-Fletcher, Edwin. (2016). In silico Clinical Trials: How Computer Simulation will Transform the Biomedical Industry. [LINK](#)
- **2022:** White paper entitled “The Role of Artificial Intelligence within In Silico Medicine”. [LINK](#)
- **2022:** Position paper entitled “Toward a Regulatory Pathway for Using In Silico Trials in CE Marking Position Paper”. [LINK](#)
- **2023:** MDIC USA - Landscape report entitled “Landscape Report & Industry Survey on the Use of Computational Modeling & Simulation in Medical Device Development”. [LINK](#)
- **2023:** In Silico UK Landscape report entitled “Unlocking the power of computational modelling and simulation across the product lifecycle in life sciences: A UK Landscape Report”. Version 2. [LINK](#)
- **2023:** Position paper entitled “The potential of in silico approaches to streamline drug development”. [LINK](#)
- **2023:** Viceconti M., De Vos M., Mellone S., Geris L., Position paper From the digital twins in healthcare to the Virtual Human Twin: a moon-shot project for digital health research. IEEE J Biomed Health Inform. 2023 Oct 11;PP. Epub ahead of print. PMID: 37819828. [LINK](#)

## 3.5.2

# Key publications on in silico trials

### ***In silico trials***

- **2024:** Pathmanathan, P., Aycock, K.I., Badal, A., Bighamian, R., Bodner, J., Craven, B.A., et al. Credibility assessment of in silico clinical trials for medical devices. PLoS Comput Biol. 2024;11. [LINK](#)
- **2024:** Aycock K.I., Battisti T., Peterson A., Yao J., Kreuzer S., Capelli C., Pant S., Pathmanathan P., Hoganson D.M., Levine S.M. and Craven B.A. (2024) Toward trustworthy medical device in silico clinical trials: a hierarchical framework for establishing credibility and strategies for overcoming key challenges. Front. Med. 11:1433372. [LINK](#)
- **2024:** Toward Good Simulation Practice: Best practices for the use of computational modelling & simulation in the regulatory process of biomedical products. In: Synthesis Lectures on Biomedical Engineering. Viceconti M. & Emili L. (Eds.), Springer Cham eBook. ISBN: 978-3-031-48283-0, 2024. [LINK](#)

- **2021:** Viceconti M., Emili L., Afshari P., Courcelles E., Curreli C., Famaey N., Geris L., Horner M., Jori M.C., Kulesza A., Loewe A., Neidlin M., Reiterer M., Rousseau C.F., Russo G., Sonntag S.J., Voisin E.M., Pappalardo F. Possible Contexts of Use for *in silico* trials Methodologies: A Consensus-Based Review. IEEE J Biomed Health Inform. 2021 Oct;25(10):3977-3982. [LINK](#)
- **2021:** M. Viceconti, F. Pappalardo, B. Rodriguez, M. Horner, J. Bischoff, and F. M. Tshinanu, "In silico trials: Verification, validation and uncertainty quantification of predictive models used in the regulatory evaluation of biomedical products," Methods, vol. 185, pp. 120–127, 2021. [LINK](#)

### **Regulatory reports from In Silico World consortium**

- Viceconti, M., Pappalardo, F., Curreli, C., Russo, G., & Aldieri, A. (2024). Regulatory Barriers to the adoption of in silico trials (Version v1). Zenodo. [LINK](#)
- Viceconti, M., Curreli, C., Aldieri, A., & Pappalardo, F. (2024). BBCT-Hip Qualification advice with EMA - Public Domain Documents (Version v1). Zenodo. [LINK](#)
- Pappalardo, F., Viceconti, M., Curreli, C., & Russo, G. (2024). UISS-TB Qualification advice with EMA - Public Domain Documents (Version v1). Zenodo. [LINK](#)

# Conclusion

*In silico* medicine represents the **future of healthcare** and has entered into a phase of rapid innovation where real-life applications, although not yet routinely included in regular clinical practice, are becoming increasingly frequently used. It is therefore fundamental to **engage with a variety of stakeholders**, including patients, clinicians, policymakers, and industry, involving them in all stages of the research and innovation process.

The document's authors aimed to provide a set of useful tools and resources to the research community to foster a fruitful engagement with different stakeholder categories.

This is a **living document**, and will be continuously updated. The authors invite the entire community and all stakeholders to contribute their materials and experience to further enhance and enrich this infokit.

The VPH - The Society for In Silico Medicine is also interested in learning from the readers' experiences when implementing some of the mentioned tools and resources for their product or project. If you'd like to participate in this collective effort, please contact us at [✉ admin@vph-institute.org](mailto:admin@vph-institute.org).



# References

1. Felt, Ulrike, et al. "Doing Co-creation: Power and Critique in the Development of a European Health Data Infrastructure." *Journal of Responsible Innovation*, vol. 10, no. 1, Jan. 2023, [LINK](#).
2. Price, Amy, et al. "Patient and Public Involvement in Research: A Journey to Co-production." *Patient Education and Counseling*, vol. 105, no. 4, July 2021, pp. 1041–47. [LINK](#).
3. Cordeiro, João V. "Digital Technologies and Data Science as Health Enablers: An Outline of Appealing Promises and Compelling Ethical, Legal, and Social Challenges." *Frontiers in Medicine*, vol. 8, July 2021, [LINK](#).
4. Hartwig, Tilman, et al. "Artificial Intelligence ELSI Score for Science and Technology: A Comparison Between Japan and the US." *AI & Society*, vol. 38, no. 4, Jan. 2022, pp. 1609–26. [LINK](#).
5. L'Astorina, Alba, and Monica Di Fiore, "A New Bet for Scientists? Implementing the Responsible Research and Innovation (RRI) Approach in the Practices of Research Institutions." *Relations Beyond Anthropocentrism*, vol. 5, no. 2, Nov. 2017, [LINK](#).
6. Lesage, Raphaëlle, et al. "Mapping the Use of Computational Modelling and Simulation in Clinics: A Survey." *Frontiers in Medical Technology*, vol. 5, Apr. 2023, [LINK](#).
7. Elhadj, Elisa, et al. "Brokering Responsible Research and Innovation in in Silico Medicine." *Journal of Responsible Innovation*, vol. 11, no. 1, Oct. 2024, [LINK](#).
8. Avicenna Alliance - The Association for Predictive Medicine, is a non-profit global association of industry and renowned academia/healthcare organisations, the latter represented by the VPH membership, that have a commercial or research interest in the development of in silico medicine.
9. Niederberger, Marlen, and Julia Spranger. "Delphi Technique in Health Sciences: A Map." *Frontiers in Public Health*, vol. 8, Sept. 2020, [LINK](#).
10. Linstone, Harold A., and Murray Turoff. *The Delphi Method: Techniques and Applications*. 1975, [LINK](#).
11. Major and Savin-Baden & Howell Major, C. "Qualitative Research: The Essential Guide to Theory and Practice". Routledge, 1st ed. [LINK](#).

12. Batya Friedman and David G. Hendry, Value Sensitive Design: Shaping Technology with Moral Imagination (MIT Press, 2019), [LINK](#).
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16. Stalmeijer, Renée E., et al. "Using Focus Groups in Medical Education Research: AMEE Guide No. 91." Medical Teacher, vol. 36, no. 11, July 2014, pp. 923–39. [LINK](#).
17. Life Sciences & Society Lab at KU Leuven.
18. [In Silico World Project](#) and [EDITH-CSA](#).
19. Elhadj, E., Van Horenbeeck, Z., Lievevrouw, E., & Van Hoyweghen, I. "Brokering Responsible Research and Innovation in in Silico Medicine." Journal of Responsible Innovation, vol. 11, no. 1, Oct. 2024, [LINK](#).
20. Geris, L., Rousseau, C.F., Noailly, J., Afshari, P., Auffret, M., Chu, W., De CunhaBurgman, M., Lafon, Y., Marchal, T., Palmer, M., Voisin, E.M., Viceconti, M., Hoekstra, A.G., Johnston, G., Alessandrello, R., Bril, A., Dall'Ara, E., Kulesza, A., Lesage, R., Martin, B., Reiterer, M., Waterkeyn, A. (2022). "WHITE PAPER: the role of Artificial Intelligence within in silico medicine." Zenodo. [LINK](#).
21. Musuamba, Flora T., et al. "Scientific and Regulatory Evaluation of Mechanistic in Silico Drug and Disease Models in Drug Development: Building Model Credibility." CPT Pharmacometrics & Systems Pharmacology, vol. 10, no. 8, June 2021, pp. 804–25. [LINK](#).



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