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White Paper: Clinical Research

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Schweizerische Akademie der Medizinischen Wissenschaften
Académie Suisse des Sciences Médicales
Accademia Svizzera delle Scienze Mediche
Swiss Academy of Medical Sciences

Information on the elaboration of the white paper

The working group in charge of the elaboration of the white paper was set up by the Executive Board of the Swiss Academy of Medical Sciences (SAMS) in 2019 with a mandate from the State Secretariat for Education, Research and Innovation (SERI). The working group consisted of one chair (Prof. Claudio L. Bassetti, Bern) and 16 members with different backgrounds and areas of expertise in clinical research, including a patient representative, a professor for Nursing Science, and an early career clinical researcher. A core editorial group, supported by the SAMS General Secretariat, was created to facilitate the writing process. The working group held six meetings, with several additional meetings of the editorial group. The white paper draft was reviewed by a sounding board involving national and international experts. National experts were additionally invited to comment on the draft during a hearing on 26 October 2020. The final version of the white paper was approved by the SAMS Executive Board on 3 May 2021.

More information on the reflections that led to the creation of the working group are given in Chapter 2. Its composition and the list of experts involved in the manuscript review are available in Appendix 2.

White Paper:
Clinical Research

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SDGs: The international sustainability goals of the UNO
With this publication, the Swiss Academy of Medical Sciences contributes to SDG 3: «Ensure healthy lives and promote well-being for all at all ages.»

› sustainabledevelopment.un.org
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› English › The 2030 Agenda › 17 Sustainable Development Goals

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Executive Summary – English

Patient-oriented clinical research in Switzerland has improved in the last 20 years, but still lags behind basic and experimental research and, in international comparison, behind leading countries. Although support entities, infrastructures, and seed funding have expanded with public investments, there remain deficits in the Swiss clinical-research landscape.

Mandated by the State Secretariat for Education, Research and Innovation (SERI) and in collaboration with experts from various clinical research backgrounds, the Swiss Academy of Medical Sciences (SAMS) elaborated this white paper to present a concerted vision on how to use resources more efficiently, align efforts on common, overarching priorities, and, more generally, address the current challenges for clinical research in our country.

The white paper describes the present state of Swiss clinical research, identifies the major driving forces that are transforming it, and formulates goals, recommendations, and measures to foster the clinical research culture and create optimal conditions to increase its benefit for patients and all sectors of society in the future.

Considering the main stakeholders of the research landscape, fragmentation, overlaps, decentralized structures, regulatory hurdles, and a lack of shared strategic priorities are evident. A national alignment and coordination of efforts is essential to improve the quality and impact of clinical research.

Stronger involvement from patients and citizens in clinical research, and a direct engagement between scientists and the public is needed to promote education and an effective knowledge transfer that will benefit society as a whole.

Based on the notion that good care comes with – and from – good science, the clinical research culture must be strengthened in hospitals and related research institutions. This will contribute to the development of a «learning healthcare system». To reach this goal, the education, training, mentoring and support of medical and other clinical researchers at all career levels is of paramount importance. In addition, interdisciplinary and interprofessional teams, involving patients and citizens, and integrating the perspectives of public health, technology, economics and industry experts, must be fostered.

Clinical research methods should be expanded to include innovative clinical trial designs, precision medicine, digital, and technological approaches. To promote health data science and personalized health, substantial efforts are needed to harmonize, at a national level, data-related guidelines, to build infrastructures facilitating interoperability between research and clinical stakeholders and to increase the availability of population cohort data within a clearly defined legal framework. Increasing regulatory requirements need to be dealt with in a cross-institutional and cross-cantonal fashion, in compliance with international standards.

Based on these considerations, the white paper outlines the following seven goals which constitute an action plan for change to make Switzerland an international leader in patient-centered clinical research:

1. Create a national platform to coordinate publicly funded stakeholders in clinical research
2. Establish strong partnerships with society, citizens, and patients
3. Promote a healthcare system that systematically integrates clinical research: good care comes with – and from – good science
4. Invest in the development of innovative and dynamic clinical research approaches, designs, and technologies enabled by digital tools
5. Strengthen translational, multidisciplinary, and integrated clinical research teams
6. Ensure an environment that is attractive to clinical and health researchers and support them at all career levels
7. Increase the efficiency and accelerate the delivery of clinical research by reducing the complexity of regulatory and data-related processes

Primarily addressed to governmental and institutional stakeholders, a roadmap sets out a series of actions to make the white paper vision for the future of clinical research a reality. Reaching these goals requires the active participation of all those who benefit from clinical research – patients and society as a whole – and clear political support.

Executive Summary – Deutsch

Die patientenorientierte klinische Forschung hat sich in der Schweiz in den letzten zwanzig Jahren verbessert. Trotzdem liegt sie hinter der Grundlagen- und experimentellen Forschung und im internationalen Vergleich hinter den führenden Ländern zurück. Obwohl Fördereinrichtungen, Infrastrukturen und Anschubfinanzierungen mit öffentlichen Geldern ausgebaut wurden, bleiben Defizite in der klinischen Forschungslandschaft der Schweiz bestehen.

Im Auftrag des Staatssekretariats für Bildung, Forschung und Innovation (SBFI) und in Zusammenarbeit mit Expertinnen und Experten aus verschiedenen Bereichen der klinischen Forschung hat die Schweizerische Akademie der Medizinischen Wissenschaften (SAMW) dieses White Paper erarbeitet. Es präsentiert die Vision, wie die Ressourcen effizienter genutzt, die Aktivitäten an gemeinsamen übergreifenden Prioritäten ausgerichtet und die aktuellen Herausforderungen der klinischen Forschung bewältigt werden können.

Das White Paper beschreibt den heutigen Stand der klinischen Forschung in der Schweiz, identifiziert die treibenden Kräfte, die sie verändern, und formuliert Ziele, Empfehlungen und Massnahmen, wie die klinische Forschungskultur gefördert und optimale Bedingungen geschaffen werden können, um den Nutzen für Patientinnen, Patienten und die Gesellschaft insgesamt zu steigern.

Mit Blick auf die Hauptakteure der Schweizer Forschungslandschaft sind Fragmentierung, Überschneidungen, dezentrale Strukturen, regulatorische Hürden und ein Mangel an gemeinsamen strategischen Prioritäten offensichtlich. Eine nationale Abstimmung und Koordination der Aktivitäten ist unerlässlich, um die Qualität und Wirkung der klinischen Forschung zu verbessern.

Eine stärkere Einbindung von Patientinnen, Patienten und der gesunden Bevölkerung in die klinische Forschung sowie ein aktiver Austausch zwischen Wissenschaft und Öffentlichkeit sind nötig, um das Verständnis und einen effektiven Wissenstransfer zum Nutzen für die gesamte Gesellschaft zu fördern.

Überzeugt, dass gute medizinische Versorgung mit und von guter Wissenschaft kommt, muss die klinische Forschungskultur in Spitälern und den zugehörigen Forschungseinrichtungen gestärkt werden. Um das Ziel eines «lernenden Gesundheitssystems» zu erreichen, sind Ausbildung, Training, Mentoring und die Förderung von medizinischen und anderen klinischen Forschenden auf allen Karrierestufen von zentraler Bedeutung. Darüber hinaus gilt es interdisziplinäre und interprofessionelle Teams aufzubauen, die Patienten und Bürgerinnen einbeziehen und Know-how aus der öffentlichen Gesundheit, Technologie, Ökonomie und Industrie integrieren.

Die Methoden der klinischen Forschung sind durch innovative klinische Studiendesigns, Präzisionsmedizin, digitale und technologische Ansätze zu erweitern. Zur Förderung von Health Data Science und personalisierter Gesundheit sind erhebliche Anstrengungen auf nationaler Ebene notwendig, um datenbezogene Richtlinien zu harmonisieren, um Infrastrukturen aufzubauen, die die Interoperabilität zwischen Forschungs- und klinischen Akteuren erleichtern, und um den Zugang zu Daten von Bevölkerungskohorten in einem klaren rechtlichen Rahmen zu verbessern. Die steigenden regulatorischen Anforderungen müssen institutions- und kantonsübergreifend und in Übereinstimmung mit internationalen Standards behandelt werden.

Basierend auf diesen Überlegungen skizziert das White Paper die folgenden sieben Ziele im Sinne eines Aktionsplans, um die Schweiz als international führendes Land in der patientenzentrierten klinischen Forschung zu etablieren:

1. Schaffung einer nationalen Plattform zur Koordination öffentlich finanzierter Akteure in der klinischen Forschung
2. Aufbau starker Partnerschaften mit der Öffentlichkeit, der Bevölkerung, Patientinnen und Patienten
3. Förderung eines Gesundheitssystems, das die klinische Forschung systematisch integriert: Good care comes with – and from – good science
4. In die Entwicklung von innovativen, dynamischen klinischen Forschungsansätzen, Designs und Technologien investieren
5. Translationale, multidisziplinäre und integrierte klinische Forschungsteams fördern
6. Ein Umfeld gewährleisten, das für klinisch Forschende und Gesundheitsforschende attraktiv ist und sie auf allen Karrierestufen unterstützt
7. Die Komplexität der regulatorischen und datenbezogenen Prozesse reduzieren, um die Effizienz zu steigern und die Umsetzung klinischer Forschung zu beschleunigen

Eine Roadmap, die sich in erster Linie an staatliche und institutionelle Akteure richtet, präsentiert Massnahmen, um die im White Paper vorgestellte Vision der klinischen Forschung zu verwirklichen. Für die erfolgreiche Umsetzung ist die aktive Beteiligung all jener nötig, die von klinischer Forschung profitieren – Patientinnen, Patienten und die Gesellschaft als Ganzes –, und eine klare politische Unterstützung unerlässlich.

Executive Summary – Français

La recherche clinique orientée vers les patient-e-s s'est améliorée en Suisse au cours des vingt dernières années, mais elle accuse encore du retard par rapport à la recherche fondamentale et expérimentale et, en comparaison internationale, par rapport aux pays leaders. Bien que des entités de soutien, des infrastructures et des financements incitatifs aient été développés grâce à des investissements publics, des déficits subsistent dans le paysage de la recherche clinique suisse.

Sur mandat du Secrétariat d'État à la formation, à la recherche et à l'innovation (SEFRI) et en collaboration avec des expert-e-s issus de divers domaines de la recherche clinique, l'Académie Suisse des Sciences Médicales (ASSM) a élaboré ce White Paper pour présenter une vision concertée sur la manière d'utiliser les ressources plus efficacement, d'aligner les efforts sur des priorités communes et – plus généralement – de relever les défis de la recherche clinique dans notre pays.

Le White Paper décrit l'état actuel de la recherche clinique en Suisse, identifie les principales dynamiques qui la transforment et formule des objectifs, des recommandations et des mesures visant à développer la culture de la recherche clinique et à créer des conditions optimales pour que les patient-e-s et tous les secteurs de la société en bénéficient davantage à l'avenir.

Si l'on considère les principaux acteurs du paysage de la recherche, la fragmentation, les redondances, les structures décentralisées, les obstacles réglementaires et l'absence de priorités stratégiques communes sont manifestes. Une concertation et une coordination des efforts au niveau national sont essentielles pour améliorer la qualité et l'impact de la recherche clinique.

Une plus grande implication des patient-e-s et des citoyen-ne-s ainsi qu'un échange direct entre les scientifiques et le public sont nécessaires pour promouvoir l'éducation et un transfert efficace des connaissances au profit de la société toute entière.

Fondée sur la conviction que la qualité des soins dépend et découle d'une science de qualité, la culture de la recherche clinique doit être renforcée dans les hôpitaux et les institutions de recherche qui leur sont associées. Cela dans le but de développer un «système de santé apprenant». Pour atteindre cet objectif, l'éducation, la formation, le mentorat et le soutien des chercheuses et chercheurs cliniques avec des profils divers, à toutes les étapes de leur carrière, sont essentiels. Par ailleurs, il faut encourager les équipes interdisciplinaires et interprofessionnelles, impliquer les patient-e-s et les citoyen-ne-s, et intégrer la perspective des expert-e-s en santé publique, en technologie, en économie, et de l'industrie.

Les méthodes de recherche clinique doivent être élargies pour inclure des types d'essais cliniques innovants, la médecine de précision, les approches numériques et technologiques. Pour promouvoir la recherche basée sur les données de santé et la santé personnalisée, des efforts substantiels sont nécessaires pour harmoniser, au niveau national, les directives relatives aux données, pour créer des infrastructures facilitant l'interopérabilité entre les acteurs de la recherche et de la clinique, et pour augmenter l'accès aux données de cohortes de population à l'intérieur d'un cadre juridique clairement défini. Les exigences réglementaires croissantes doivent être traitées de manière interinstitutionnelle et intercantonale, dans le respect des normes internationales.

Sur la base de ces considérations, le White Paper définit sept objectifs qui constituent un plan d'action pour faire de la Suisse un pays leader de la recherche clinique centrée sur les patient-e-s au niveau international:

1. Créer une plateforme nationale de coordination des acteurs publics de la recherche clinique
2. Établir des partenariats solides avec la société, les citoyen-ne-s et les patient-e-s
3. Promouvoir un système de soins qui intègre systématiquement la recherche clinique: Good care comes with – and from – good science
4. Investir dans le développement d'approches, de méthodes et de technologies innovantes et dynamiques en recherche clinique, rendues possibles par le numérique
5. Renforcer les équipes de recherche clinique translationnelles, multidisciplinaires et intégrées
6. Assurer un environnement attrayant pour les chercheuses et chercheurs clinicien-ne-s et du domaine des soins qui les soutiennent à tous les niveaux de carrière
7. Réduire la complexité des processus règlementaires et de ceux liés aux données pour augmenter l'efficacité et accélérer la mise en application de la recherche clinique

Une feuille de route, qui s'adresse en premier lieu aux acteurs étatiques et institutionnels, définit une série de mesures pour faire de la vision de l'avenir de la recherche clinique, telle que présentée dans le White Paper, une réalité. Pour atteindre ce but, l'engagement des bénéficiaires de la recherche clinique – les patient-e-s et les citoyen-ne-s – et un clair soutien politique seront essentiels.

1. Introduction

1.1 Definition

Clinical research is understood here as scientific investigations with or on humans (patients and healthy people) as well as research involving material of human origin and health-related personal data aiming to improve health, and the prevention, diagnosis, cure, and care of diseases.

Clinical research includes translational studies; quality-controlled experimental and/or observational scientific investigations on human health, well-being, physiology, pathophysiology, and disease; epidemiologic and behavioral studies; outcomes or health services research; studies on the development of new technologies; clinical trials; and implementation research.

1.2 Background

In 1992, clinical research in Switzerland was considered a "problem" in international comparison by Bühler and Burri (1). Accordingly, in 1993, the Swiss Academy of Medical Sciences (SAMS) made four recommendations to the Swiss National Science Foundation (SNSF) to improve the situation.

In 2002, a task force of the Swiss Science Council considered the situation to be improved but still not satisfactory (2,3). The following main problems were identified: 1) Switzerland is small and collaborations between institutions are weak; 2) lack of clinical scientists (insufficient time, career, or promotion options, no dedicated MD-PhD programs); and 3) health systems and clinical research are both under the control of the same political institution (hospitals in particular). Although a lack of bibliometric data to assess the situation was acknowledged, clinical research was considered less successful than basic research in Switzerland.

To improve the situation, four recommendations were made: 1) establishment of training grants; 2) coordination of teaching and research by universities, not hospitals; 3) creation of combined clinical/research positions, supported in part by the SNSF; 4) promotion of clinical research careers also for non-MDs.

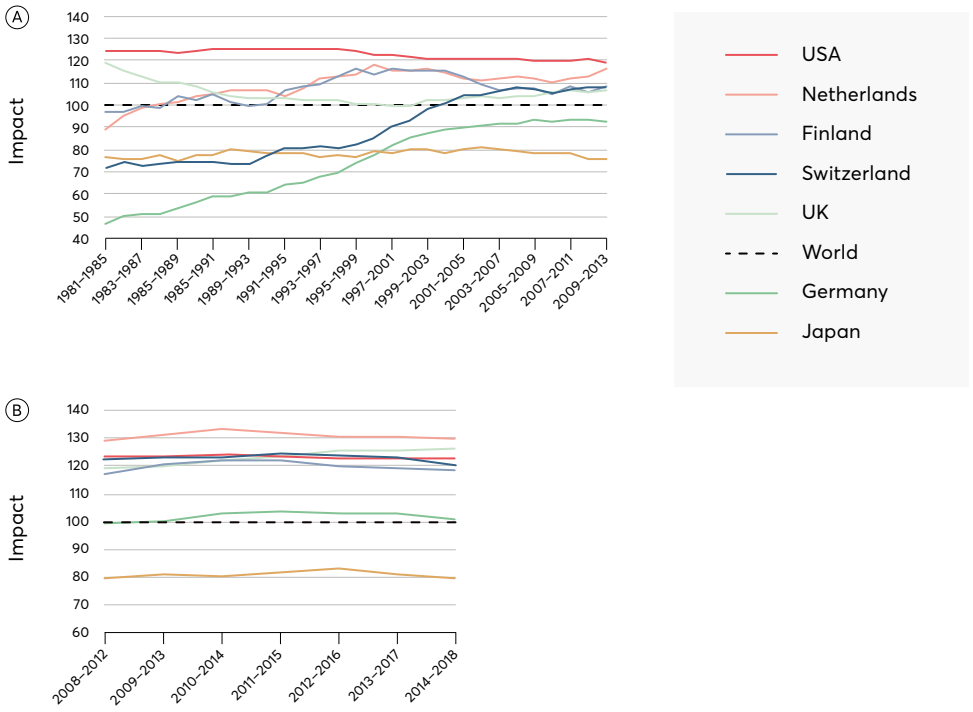
In its 2004–2007 program the SNSF recognized clinical/patient-oriented research as a priority. This led to the seed funding of Clinical Trials Units (CTUs), the Swiss Clinical Trial Organization (SCTO), and the Program for Longitudinal Studies, which supported studies based on data generated by long-term follow-up of cohorts. In the last 10 years, further investments have followed such as the creation of a national health research data infrastructure (Swiss Personalized Health Network (SPHN)), support for biobanks (Swiss Biobanking Platform (SBP)), the launch of MD-PhD programs devoted to clinical research, and the promotion of Investigator Initiated Clinical Trials (IICTs).

1.3 Current situation

Today, 29 years after Bühler and Burri's paper (1), clinical research in Switzerland has clearly improved. This is illustrated by indicators such as the number of citations per publication in clinical medicine in international comparison (Fig. 1), as well as when compared to other disciplines in Switzerland (Appendix 1, Fig. A1). Academic institutions and foundations have also set up several initiatives to support young clinical scientists (4).

Nevertheless, the situation can still be considered unsatisfactory. This is illustrated by the following facts: 1) the success rate of clinical research projects at the SNSF has remained lower than that of non-clinical projects, indicating issues concerning the feasibility and quality of clinical research proposals (Fig. 2A); 2) the proportion of SNSF funding supporting basic research has steadily increased (Fig. 2B); 3) the number of clinical scientists with adequate training (e.g., in designing and running clinical trials) remains insufficient (5,6); and 4) the number of clinical trials performed in Switzerland has decreased, which may be also a consequence of the increased regulatory/quality demands and administrative burden (Fig. 3).

Figure 1: Evolution of the impact of Swiss clinical medicine publications in comparison with strong clinical research nations for the periods 1981–2013 (A) and 2008–2018 (B).
To calculate impact (relative citation indicator), the absolute number of citations received by publications is set against the world average of citations per publication. This relative indicator is then standardized on a scale of 0 to 200, where 100 represents the world average. Compared to the United Kingdom, Germany, the Netherlands, Finland, and Japan, Switzerland is well-positioned. Since the early 2000s, however, Switzerland's position has stagnated: when compared to the strongest countries (the Netherlands and UK), there remains room for improvement. Impact data were calculated based on the data present in three "simple" databases (SCI, SSCI, and A&HCI; up to 2016), and based on the "expanded" versions of these databases plus the ESCI database (from 2016).



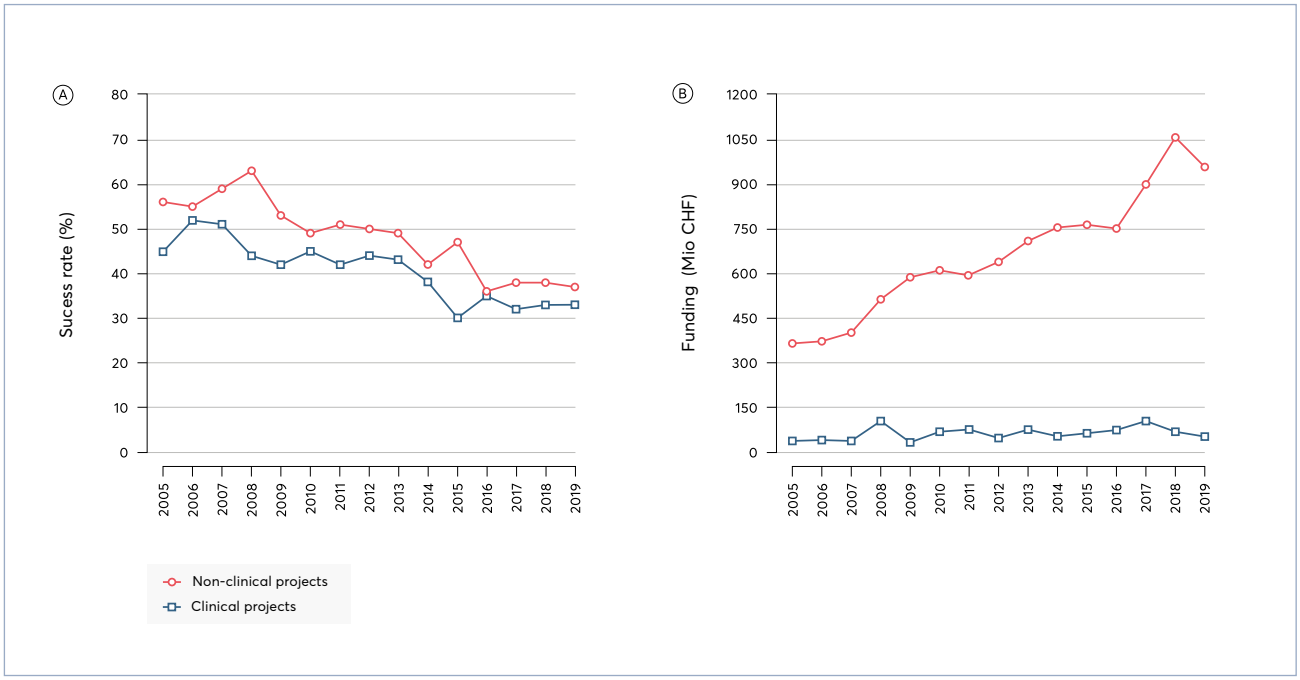
Source: SERI 2020, Clarivate Analytics Data.

Despite the high quality of medical care in Switzerland, the quality of clinical research still lags behind that of basic/experimental research. The following factors may contribute to this notion:

Firstly, the involvement of patients and of the general public is limited. Secondly, clinical research is not regarded as equally important as clinical duties – it is not paid equally nor does it contribute equally to one's career trajectory. Specialists with the necessary training, such as clinical MD-PhDs, are insufficiently supported and have no significant career advantage; protected research time during residency programs and attractive career options for clinician scientists are often lacking. Furthermore, the expectations of new generations (e.g., concerning work-life balance) have significantly changed yet women remain underrepresented in advanced clinical research positions (7). Thirdly, the financial burden in the healthcare system has grown, decreasing hospitals' interest in clinical research. In parallel, the administrative and legal requirements for clinical research have greatly increased, thus resulting in higher costs. Fourthly, scientific efforts and initiatives launched in the past years to promote clinical research in Switzerland have often remained fragmented due to a lack of national research strategies and conflicting local and cantonal policies.

Lastly, when compared to competitors worldwide, the small size of academic institutions and hospitals, the lack of health data linkage opportunities, and the timid public funding of biotech innovation all stand in the way of improving the quality of clinical research in Switzerland.

Figure 2: Success rates and funding at the SNSF for clinical and non-clinical research projects.
The success rate is defined as the percentage of approved projects in the total number of submitted projects. From 2005–2019 the success rate was lower for clinical research projects compared to non-clinical research projects, with an average success rate of 41 % and 48 %, respectively (A). From 2005–2019, the SNSF has allocated on average 62 Mio CHF or 10 % of its budget per year to clinical research projects, amounting to 985 Mio CHF for the time period (B). Even though funding increased for non-clinical projects, their success rate decreased progressively. In both figures, the numbers comprise the budgets of clinical research projects (1) in the main disciplines clinical medicine, preventive medicine, and social medicine of the relevant funding instruments in the Career Funding and Programs Divisions; (2) clinical projects in the project funding scheme in the Biology and Medicine Division, as well as (3) projects in special programs in medicine) compared to all disciplines supported by the SNSF.



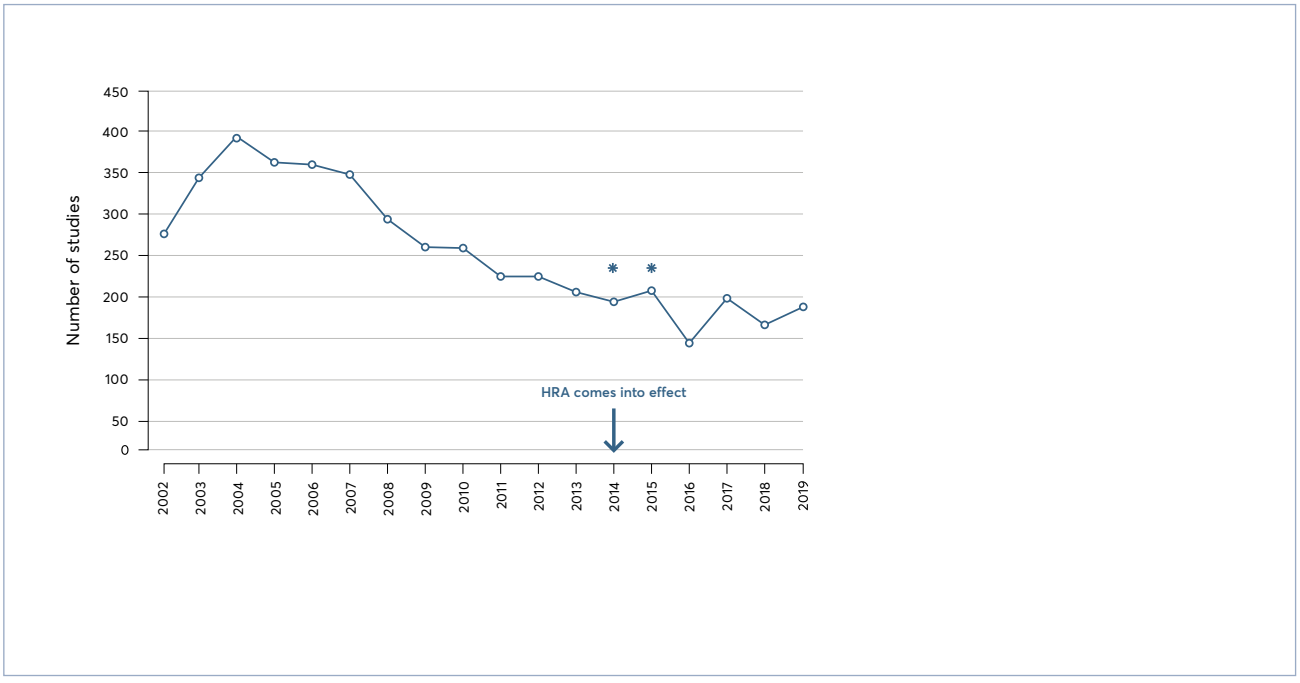
Source: SNSF, Biology and Medicine Division, 2020.

1.4 Aim of the White Paper

This paper addresses three main questions concerning clinical research in Switzerland: 1) what is the present state (including achievements, challenges, overlaps, and redundancies)?; 2) what is the target state (main drivers and trends of clinical research)?; 3) which goals and recommendations can be made to reach the target state?

Based on the notions that good care comes with – and from – good science, the overall aim of the paper is to formulate concrete measures to make Switzerland an international leader in high-quality clinical research that is impactful for patient care.

Figure 3: Evolution of the number of clinical trials performed in Switzerland.
The evolution of the number of clinical trials approved in Switzerland shows a clear downwards trend in recent years, stabilizing at a low level.
* Please note that since the introduction of the Human Research Act in 2014, only a subset of clinical trials have to be registered at Swissmedic (i.e., clinical studies with medicinal products and transplant products of risk categories B and C, but no longer those of categories A and D). As studies were initially not categorized by local Ethics Committees according to the same criteria, the data for 2014 and 2015 are incomplete and represent only the subset of trials approved by Swissmedic.



Source: Data extracted from swissmedic annual reports (2002–2015), BASEC (2016), and provided by FOPH (2017–2019, Kofam statistical report 2019).

2. Methodology

The reflection on clinical research and its development in Switzerland has been a strategic priority of the SAMS for many years and has led to the publication of several position papers on the topic. During its spring retreat in 2019, the SAMS Executive Board concluded that, despite the setup of numerous structures, initiatives, and funding opportunities to promote clinical research in Switzerland in recent years, these efforts were still largely scattered and had led to redundancies, a fragmented landscape, inefficient use of resources, and unresolved gaps. This observation, shared by other actors of clinical research, gave the impetus to set up a broadly based working group to draft recommendations on how to coordinate activities more efficiently and better use existing resources. Following a meeting with national clinical research stakeholders, the SAMS was given a mandate from the State Secretariat for Education, Research and Innovation (SERI) in December 2019 to elaborate a strategic white paper presenting a consolidated vision for the future of clinical research in Switzerland and to provide inputs for the Masterplan Biomedicine (Masterplan ''Massnahmen des Bundes zur Stärkung der biomedizinischen Forschung und Technologie 2021–2025'') by early 2021. A Swiss-focused view to address the heterogeneity of the clinical research landscape was thus deliberately chosen. Given the tight schedule, detailed international benchmarking and an in-depth analysis of clinical research quality and output in Switzerland were considered outside the scope of this paper. While the primary focus of this paper is, for practical reasons, on clinical scientists, patients, and society, the central role of other health professionals, researchers, industry, and further actors of the clinical research cycle are also briefly addressed by the working group in this document.

The working group in charge of the elaboration of the white paper consisted of one chair (Prof. Claudio L. Bassetti, Bern) and 16 members with different backgrounds and areas of expertise in clinical research, including a patient representative, a professor for Nursing Science, and an early career clinical researcher. A core editorial group, supported by the SAMS General Secretariat, was created to facilitate the writing process. The working group held six meetings, with several additional meetings of the editorial group. The white paper draft was reviewed by a sounding board involving national and international experts. National experts were additionally invited to comment on the draft during a hearing on 26 October 2020. The final version of the white paper was approved by the SAMS Executive Board on 3 May 2021.

The composition of the working group and the list of experts involved in the manuscript review are available in Appendix 2.

3. Present state

3.1 Main actors of academic clinical research at the national level/review of national initiatives

This chapter presents the main actors of academic clinical research at the national level, their mandates, and main challenges. A detailed description can be found in Appendix 3. We focus here on the initiatives and research infrastructures that have been set up with federal investments to improve the framework conditions for clinical research since 2002. As the recommendations formulated in this paper consider the critical interfaces between national and local academic actors, the important contributions of universities and research hospitals, while funded and regulated mostly at the cantonal level, are briefly presented in chapter 3.2.

Swiss National Science Foundation (SNSF)

Mandate and main achievements

The SNSF supports scientific research in all academic disciplines and is the main Swiss institution for promoting scientific research. At the end of 2019, the SNSF was funding 5750 projects involving 18,900 researchers. The SNSF strives to create optimal conditions for the development and international integration of Swiss research. It pays particular attention to the promotion of young researchers. Over the period 2005–2019, the SNSF allocated on average 62 Mio CHF per year to clinical research projects, representing on average 10 % of the total yearly SNSF funding, amounting to 985 Mio CHF for the time period (Fig 2). Special programs dedicated to clinical research have been initiated and supported in the same period for a total amount of 231 Mio CHF. These included, among others, grants for longitudinal studies, the special program "Universitäre Medizin", and the "Investigator Initiated Clinical Trials (IICT)" program.

Main challenges

- The quality of the clinical research proposals is often still insufficient;
- A significant proportion of SNSF-funded clinical trials are prematurely discontinued or do not get published in peer-reviewed journals (8);
- Scientific evaluation of clinical research grants does not yet require binding confirmation by institutions to ensure sufficient protected research time for the applicants;
- Success and funding rates of clinical proposals evaluated in the Biology and Medicine Division project funding scheme are 20 % lower than those of basic research (see Appendix 1, Fig. A2). Factors contributing to this include 1) the high methodological standards of clinical trials and the lack of acquisition of professional qualifications and competencies for the studies; 2) insufficient protected time for clinicians to prepare and implement clinical trials; and 3) the direct comparison and competition with basic research with its focus on innovation and novelty;
- Appropriate response to increased budget needs from a potential growing number of high-quality clinical research proposals;
- Lack of sufficient funding for MD-PhD students and PhD students in other health disciplines such as nursing sciences, to perform patient-oriented research.

Swiss Clinical Trial Organisation (SCTO)

Mandate and main achievements

The SCTO was founded in 2009 as a joint initiative of the SNSF and the SAMS with the aim to act as the central cooperation platform for patient-oriented clinical research in Switzerland. The mandate included the coordination and cooperation between the clinical research centres (clinical trial units (CTUs)), building up a national, distributed clinical research infrastructure.

The SCTO fulfills its mandate by facilitating continuing education, supporting the formation of national networks and the integration of national clinical research into international networks, advocating patient involvement, strengthening the communication between experts and the general public, and building bridges between academia, industry, and public authorities.

In 2019, the CTU network supported 2066 clinical research projects and provided support on research methods, data management, statistics, monitoring, project management, and regulatory affairs. Projects covered the entire spectrum of patient-oriented research activities. The CTU network is also the main provider of education and continuous training in clinical research in Switzerland.

Main challenges

- Many clinical studies cannot be supported by a CTU since they lack an approporiate budget for CTU support;
- Increasing need for scientific and regulatory support for smaller, poorly funded research projects are a

challenge to CTUs (e.g., Human Research Ordinance [HRO] studies without a competitive funding source);
– It would be ideal if the SCTO could act as a single point of contact to help organize multicenter clinical trials, supporting the networking between centers, and establishing bottom-up local infrastructures;
– Funding for national SCTO platforms and local CTU activities is currently not sustainable, but is a prerequisite to further development of the network.

Swiss Personalized Health Network (SPHN)

Mandate and main achievements

The SPHN initiative of the State Secretariat for Education, Research and Innovation (SERI) and the Federal Office of Public Health (FOPH) was launched in 2016 to support the development of clinical health-relevant data infrastructures to make health-relevant data interoperable and broadly accessible for research. The SPHN sets up nationally coordinated infrastructures to efficiently manage, exchange, and process consented health data in accordance with ethical and legal requirements, with a total budget of 68 Mio CHF for the period 2017–2010 and 67 Mio CHF for 2021–2024. The SPHN has adopted a federal approach by building upon and supporting existing data sources and infrastructures across the country.

To support the development of compatible clinical data management systems – to make health-related data interoperable and shareable at a national level according to FAIR principles[1] – the SPHN has initiated "infrastructure implementation projects" with the five university hospitals and the Data Coordination Center (DCC).

Main challenges

– Sustainable funding of the established infrastructures is a major challenge: a follow-up funding period is ensured for 2021–2024 but sustainable business models are needed afterwards;
– The decisional mechanisms of SPHN governance are complex and relatively slow since the SPHN operates through collaboration of all stakeholders – the capacity to enforce decisions should be increased;
– The SPHN currently does not involve cantonal authorities in its information and decision process, yet national standards impact the health information systems at a cantonal level;
– The level of understanding in the field of clinical data interoperability is insufficient – education is required to address the key hurdles that prevent data sharing;
– The use of standardized datasets and binding data formats should be mandatory for SPHN-funded projects.

Swiss Biobanking Platform (SBP)

Mandate and main achievements

The SBP is the national coordination platform for biobanks in human and nonhuman domains. Initiated by the SNSF, the SBP was launched in response to the increasing needs of researchers in the biomedical sciences regarding biobank quality, access, transparency, and interconnectedness.

The SBP aims to coordinate biobanking and biobanking activities in Switzerland by establishing a centralized biobank registry on human and nonhuman biobanks and a sample-level catalogue to foster collaboration and sharing of biosamples. The SBP further provides technical know-how regarding, and training in, biobanking and IT management (e.g., on good biobanking practices, sampling, sample conservation, biobank governance, and information processing), information and counseling on legal and ethical aspects, and on quality and interoperability of biobanking. Moreover, the SBP links Swiss biobanks and biobank networks to the European Biobanking and Biomolecular Research Infrastructure (BBMRI-ERIC), thus constituting the Swiss national node. It also ensures the harmonization of biobanking practices with international and EU standards, and provides information on biobank networks abroad.

Main challenges

– Obtaining sustainable funding is a challenge. Funding from the SNSF is ensured for the period 2021–2024 but not beyond;
– Collaboration with and coordination of local biobank initiatives is challenging, as is getting acceptance from institutions (e.g., university hospitals) to allow the enforcement of minimal quality and interoperability standards.

Swiss Group for Clinical Cancer Research (SAKK)

Mandate and main achievements

The SAKK has conducted clinical trials in oncology since 1965 and closely collaborates with the Swiss Paediatric Oncology Group (SPOG). Supported by a service-level agreement with the SERI and by partners such

1 FAIR guiding principles for data management and stewardship specify that data must be Findable, Accessible, Interoperable, and Reusable.

as the Swiss Cancer League and Swiss Cancer Research, the SAKK performs cooperative research projects in the role of study sponsor independent of the pharmaceutical industry. It also runs clinical trials in cooperation with industry partners and with foreign groups in clinical trials. National cancer treatment centers are members of the association. With its large network, the SAKK is also the primary contact organization in Switzerland for government authorities, professional associations, and pharmaceutical companies for questions regarding clinical cancer research and acts as the Swiss service and competency center for multicenter trials in oncology. In 2019, the SAKK budget amounted to 23 Mio, comprising a federal contribution of 5.6 Mio. 21.8 Mio CHF was invested in clinical trials (interventional studies), and 0.7 Mio CHF in non-interventional research (registries, biobanks, non-interventional studies). The yearly statements of operations published in the annual reports[2] give a detailed overview of the financial contributions of SERI, the pharmaceutical industry, health insurers, the Swiss Cancer League/Swiss Cancer Research, and other private foundations.

Main challenges

- The SAKK fulfils multiple roles as sponsor of clinical trials, as quality control institution, and as coordination organ. This governance structure makes the cooperation with other, disease-agnostic clinical-research-supporting institutions difficult;
- As the financial forecast for 2021–2024 indicated an imminent, major deficit, a profound restructuring was necessary to guarantee a solid financial basis for the future;
- Innovation and new treatment options in oncology develop very fast, driving the need for increasingly complex research projects. This demand is not proportional to the financial resources for independent clinical cancer research;
- Access to innovation and clinical trials needs to be ensured for all cancer patients independent of their place of residence by strengthening the position of the SAKK.

Swiss Academy of Medical Sciences (SAMS)

Mandate and main achievements

Originally founded as a research funding institution, the SAMS acts today as a bridge builder between science and society and is part of the Swiss Academies of Arts and Sciences. The SAMS is supported by the federal government with 2.6 Mio per year (2019 budget) and develops ethical guidelines for clinical practice and clinical research, takes position on important health issues, and formulates recommendations for the attention of politicians and authorities. In addition, thanks to legates and through collaborations with private foundations, the SAMS promotes early-career clinician scientists, e.g., through national MD-PhD grants (together with the SNSF) or individual grants funding protected time for research (Young Talents in Clinical Research program).

Main challenges

- The SAMS fulfils the role of an independent moral authority but lacks operative power;
- The impact of its recommendations and their implementation in practice are not systematically measured and are difficult to evaluate;
- The SAMS operates through incentive funding programs in fields where deficits have been identified, sustainability of the funding is however not ensured;
- The SAMS should involve more young clinical researchers to include their specific needs;
- The current focus of the national MD-PhD grant program is preclinical – curriculae for clinician scientists with a primary focus on patient-oriented research as well as PhD programs for other disciplines, such as nursing science, are needed.

Federal Institutes of Technology (ETH Domain) and Personalized Health and Related Technologies Initiative (PHRT)

Mandate and main achievements

The institutions of the ETH Domain, supported with a federal budget of 10.4 Bio for the period 2017–2020, comprise ETH Zurich, EPFL Lausanne, and four research institutes (Paul Scherrer Institute (PSI), Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Swiss Federal Laboratories for Materials Science and Technology (EMPA), and Swiss Federal Institute of Aquatic Science and Technology (Eawag)). They occupy a leading international position in research and teaching in fundamental and applied scientific disciplines and have a longstanding history in biomedical research and medical-technology development. Considering the ongoing transformation of medicine into an increasingly "individualized medicine", personalized health was defined as one of ETH Domain's three strategic focus areas for the period 2017–2024. In addition, through the recently established Bachelor in Human Medicine, the ETH Domain intends

2 sakk.ch/annual-reports

to play a growing role in medical education and training in Switzerland as well as in clinical and health research.

The Personalized Health and Related Technologies (PHRT) initiative was launched in 2017, funding interdisciplinary projects in education (doctoral and postdoc level), technology translation, and research to foster the development of precision medicine and health research. PHRT also provides clinicians with access to ETH technologies. In close collaboration with the SPHN, the PHRT initiative connects hospitals and the ETH Domain institutions so that they can share, analyze, and use health data. The PHRT initiative further complements and operates in close cooperation with other programs in Switzerland, in particular, the ETH SFA Swiss Data Science Center (SDSC). It is also linked to international research efforts.

Main challenges

- ETH Domain institutions have no historical link with a medical faculty or hospital, bearing the risk that research projects are driven by technology development rather than by clinical relevance and patients' needs;
- To access clinical data and improve the implementation of research findings in clinical practice, reinforcement and further development of collaborations with university and non-university hospitals and related medical research institutions involved in clinical research will be essential;
- The paradigm change towards a data- and algorithms-driven medicine needs to be supported by a new generation of researchers and physicians able to integrate medical and scientific disciplines.

3.2 Brief overview of clinical research actors at the local level: medical faculties, university and non-university hospitals

Mandate

In Switzerland, eight medical faculties (Basel, Bern, Fribourg, Geneva, Lausanne, Neuchatel, Ticino, and Zurich) offer Bachelor and/or Master programs in Human Medicine. A new Bachelor program in Human Medicine was launched recently by ETH Zurich.

Medical faculties/universities fund the five university hospitals (Basel, Bern, Geneva, Lausanne, and Zurich) to promote teaching at the pregraduate level ("medical school") as well as fundamental and clinical research. They also fund non-hospital-based medical research institutions (e.g., ISPM Bern, Unisanté Lausanne). The total budget for research can be estimated to be around 50–100 Mio CHF per year per center.

At the five university hospitals and related medical research institutions, specific divisions or departments of education and research are mandated with the promotion and coordination of postgraduate teaching and clinical research. With the exception of Geneva, the directors of these hospital divisions/departments do not coincide with those responsible for research and teaching in the medical faculties (e.g., the vice-deans of research or education). In the last 10 years, the university hospitals have developed multiple infrastructures (data warehouses, biobanks, analytic platforms), which are also used for clinical research.

Main achievements

Over the past years, CTUs have been founded throughout Switzerland. They have promoted the culture of clinical research and greatly contributed to professionalizing the planning, conduction, and evaluation of patient-oriented clinical research. Notably, in some centers (Basel and Bern) the CTU is included in a larger department of clinical research, which further promotes clinical research.

In addition, academic institutions have set up several initiatives to support junior clinical scientists at different career stages (9). Clinical MD-PhD programs have been launched (e.g., in Bern and Basel) in which time for clinical training and clinical research is equally divided (50:50 % model). This enables participants to acquire professional qualifications and competencies within the field of clinical research in parallel to their medical specialization.

Main challenges

- The main focus of hospitals (excellence in clinical care, business/profit-oriented management) and faculties/universities (excellence in teaching and research) usually differ. Since hospitals in Switzerland often control both the practical side of healthcare and clinical research, the increasing financial burden in the health system de facto hampers the development of clinical research;
- The number of clinical scientists remains insufficient. This is partly explained by the difficulties in acquiring professional qualifications and competencies in clinical research in parallel to the medical specialization: training programs defined by the SIWF (Schweizerisches Institut für ärztliche Weiter- und Fortbildung) and national medical specialty societies give little weight to clinical research in the requirements for a clinical title. Also, the current employment conditions and career opportunities insufficiently promote research-oriented career choices; for instance, dedicating time to clinical-research-related structures and collaborations is not valued from a career perspective;

– Supporting research-oriented clinicians, nurses, physiotherapists, etc., at each stage of their career path is needed and not yet systematically guaranteed. Funds for and commitment by institutions to provide protected research time remain limited;
– A collaboration with local MD-PhD graduate schools, other PhD programs in health sciences, and the definition of minimum standards for training and competencies in clinical research are underdeveloped;
– Multidisciplinary and interdisciplinary research is not strong;
– Efficient interactions between clinical research in hospital-based and primary care settings are needed to ensure a coherent perspective throughout the entire healthcare trajectory of patients;
– The coordination of clinical-research-related initiatives (e.g., informed consent, personalized medicine, digitalization) between university hospitals and medical faculties/universities is challenging.

3.3 Interplay of actors, overlaps, and redundancies in the Swiss clinical research landscape

So far, we have presented the main academic actors of clinical research and their respective fields of action. To identify how the system can be improved, we need to take into account the environment in which clinical research is performed. In addition to the interfaces between academic institutions, interfaces with other key players must be considered. These include patients, citizens, basic researchers, industry, (cantonal) health authorities, and reimbursement decision makers.

The life cycle of clinical research relies on a complex interplay between actors and numerous national and international infrastructures at each stage of the process. For the cycle to function, actors need to work, cooperate, and collaborate according to well-defined principles and standards, and data need to be interoperable (a model of this cycle is given in Appendix 1 Fig. A3).

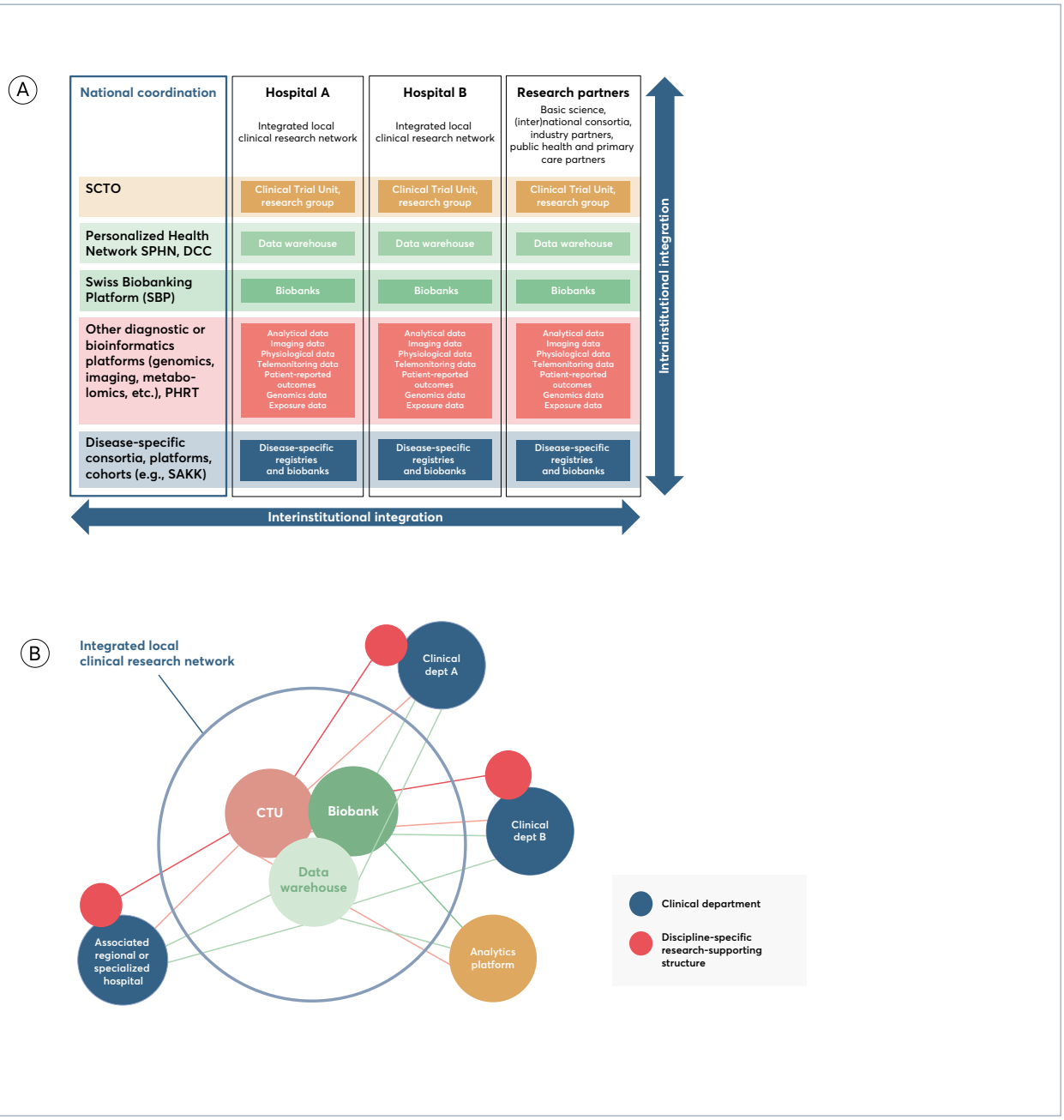
In short, the clinical research life cycle functions as follows: based on a clinical problem or a societal need, observational studies are the foundation for new scientific hypotheses. These comprise small observational studies, cross-sectional studies, case-control studies, cohort studies, personalized-health-related big data studies, or feasibility studies. The generated hypotheses then need to be tested in interventional studies, preclinical and clinical testing (phase I to III (IV)) through safety and feasibility studies, randomized controlled trials, etc. Once evidence for a novel therapy (or preventive measure) has been found, the therapy needs to be implemented into clinical practice, the real-world clinical environment, or the population (implementation studies, use-inspired studies). This stage includes socio-economic, health technology assessment, and impact studies, and requires collaboration with industry. New knowledge can also be generated through basic science experiments at this stage. Conversely, novel evidence stemming from clinical observations, intervention, and implementation studies can generate novel hypotheses for basic science (reverse translation).

Major hurdles in the Swiss clinical research landscape come from its decentralized nature and the fragmentation of national clinical research institutions: each entity has been created over the course of time with a specific purpose, within a pre-existing institutional context, and with its own hierarchy, regulatory framework, and strategic priorities. To improve the efficiency of the system as a whole, a stronger integration is needed between institutions at a local and national level and research infrastructures need to collaborate closely (see Fig. 4). Such an integration between and within institutions is a prerequisite for smoothly running multicenter trials and observational studies and to ensure the production of interoperable data for research. Similarly, clinical data infrastructures need to be highly coordinated and interconnected with basic science analytical platforms and infrastructures (translation/reverse translation), as well as with clinical data infrastructures from other centres (multicentre studies). In general, a common vision and strategy for clinical research institutions in Switzerland is required, to ensure an optimal use of competencies and resources.

To enhance the integration of the clinical research activities, one first needs to identify the main tasks and core duties of its actors, where they overlap, and where gaps exists. Figure 5 lists the major academic actors involved in clinical research as defined by their institutional mandate.

From Figure 5, it follows that a large number of actors are involved and that they partly operate in the same fields of action. When considering the institutional mandates, the table would suggest that there are no major gaps to fill. This however conflicts with the qualitative analysis

Figure 4: Integration of clinical research entities.
A, Model of desired functional (interinstitutional) and local (intrainstitutional) integration of clinical research entities. This model mainly applies to university and associated hospitals and does not represent all situations (e.g., SAKK multicenter studies). Data warehouses primarily store routine clinical data, phenotypic data (including clinical imaging and other clinical signals, PROMs) and may store administrative (including financial information), socio-economic, and structural data. B, Example of an integrated local clinical network in a university hospital.



of the current clinical research landscape, where long-term funding for key infrastructures or dedicated support instruments for early career clinician scientists are, for instance, clearly insufficient. Furthermore, the large number of actors creates numerous interfaces that add complexity to and reduce cost-effectiveness of the system.

While some level of competition might be a good driver to promote scientific excellence, it rather hinders the optimal functioning and interaction of institutions in clinical research. A crucial problem concerns the parallel elaboration of policy guidelines by different actors, since achieving a posteriori alignment on common standards through consensus building is extremely difficult. The table actually reflects the typical Swiss governance practices which operate through mandates, prescribing tasks while leaving significant leeway to individual institutions in their implementation. Despite its many advantages (bottom-up principle, knowledge of local realities and specificities, autonomy), this system cannot be steered effectively because it lacks an overarching vision as well as a central leverage to ensure coherent strategic priorities between the institutions.

Multiple initatives in recent years have promoted the creation of national clinical research networks and efforts (e.g., SCTO, SPHN, SBP, university and non-university hospitals, other medical research institutions, and disease-specific networks such as SAKK). To make the system more efficient, an alignment of priorities and activities is essential. To achieve this, a national steering coordination platform should be created. Tasks and responsabilities should be redistributed according to each actor's expertise with a clear mandate.

Chapters 4 and 5 identify where specific actions are needed to improve the system, which gaps must be filled, and how a common vision could be elaborated. Actors responsible for the implementation of the proposed measures are presented in Chapter 6.

Figure 5: Overlaps in the core activities of the main academic stakeholders of clinical research.
The attributed "+" signs reflect the priorities of each institution, not the relative amounts or the sustainability of funding. *Further institutions and authorities active at the local level are not listed as they are not the main focus of this paper.

	Institution	Core activities in the field of clinical research							
		Research funding		Infrastructure funding	Coordination services, platforms	Education, training		Promotion, advocacy patients, society, politics	Policy, governance, guidelines regulatory, ethics
		Projects	Persons			Clinical scientists	Other profiles		
national	SNSF	+++	+++	+					+
	SCTO				+++	+++	++	+++	+++
	SPHN	+		+++	+++			+	+++
	SBP			+	++			+	+++
	SAKK	++	+		+++	++	+	+++	+
	SAMS		++					+	+++
	ETH Domain	+	+	++	+	+			
	Swissethics				++				+++
local*	Med. faculties, Univ. hospitals, Res. institutions	++	+	++	++	+++			+

4. Target state: drivers and trends of clinical research

In this chapter we define the driving forces needed to reach the desired target state of clinical research in Switzerland, as identified by the experts of the working group. Overall, we believe that a national coordination among the different stakeholders, based on a consensus about research priorities, responsibilities, and tasks, is key for the development of clinical research. Stakeholders include patients, clinical researchers, and professionals from interdisciplinary clinical research networks (e.g., SCTO, CTU network, SPHN, SBP, SAKK), and are crucial for the conceptualization and performance of clinical studies, the guarantee of access to high-quality data and samples, and the definition of standards for data sharing and interoperability. Improving clinical research quality also includes improving interaction with regulatory bodies and healthcare authorities to improve and facilitate translation of clinical research into clinical practice.

From chapter 4, we distill the concrete goals, recommendations, and measures needed to achieve the target state which we present in chapter 5.

4.1 Society, citizens, and patients

A fundamental requirement for high-quality, relevant clinical research is the active involvement of its primary beneficiaries: patients and citizens. Crucially, the best possible care and prevention can be achieved only when patients and citizens are actively involved in clinical research. Involvement exceeds participation in clinical trials and data sharing. It implicates an active role of patients or patient representatives at every step of the research process: in research projects and their evaluation, and in research organizations, including ethical committees. The ongoing revision of the HRA ordinances coming into force in 2021 requests that each ethics committee includes a patient representative, establishing Patient and Public Involvement (PPI) in research (10,11).

Involving patients also contributes to creating trust in data sharing as a prerequisite for personalized health, and ultimately limits research waste. The SCTO, SBP, SPHN, SAKK and SNSF have already launched several initiatives to increase patient involvement. SAKK, for instance, founded the Patient Advisory Board in 2015 to better understand the experiences and needs of cancer patients and their relatives, and to incorporate these needs in research proposals. However these initiatives lack exchange and coordination opportunities, potentially reducing their efficiency and effectiveness. Moreover, a legal basis for collaborations between Swissmedic, patients, and consumer representatives is lacking, which hinders collaborations between these stakeholders. The regulations put in place by the European Medicines Agency (EC Regulation No 726/2004 cipher 18) regarding such collaborations may serve as an example for Switzerland.

For patients involved in clinical research and clinical trials, study procedures are often time-consuming and sometimes invasive, demanding a lot of motivation. Moreover, the patient's perspective is still often considered last when designing and conducting a clinical study. Patient motivation can be fostered when the objective of the respective study is 1) meaningful and beneficial to the patient; 2) addresses unmet health and medical needs; 3) aims to achieve patient-relevant outcomes, including both patient-reported outcome measures (PROMs) and patient-reported experience measures (PREMs), and most importantly when study participants feel that they are the main actors of the study. In general, study design needs to be transparent; studies need to be based on an evaluation of previous evidence to prevent study duplication; and timelines, group sizes, and appropriate communication methods, among other things, need to be thought through in advance. Incentives should be provided for specific replication studies wherever appropriate to facilitate and accelerate the translation of clinical evidence into clinical practice.

Another challenge is the large proportion of patients and citizens that do not wish to participate in clinical research or are not aware of this opportunity. From experiences in clinical research practice, one can estimate that the majority of the interested and aware patients do not pass the screening process (from 50 to as much as 90 %). Participation rates of population-based observational studies have declined over the past decades and is currently estimated at around one-third of the disease population. Regarding clinical trial participation, overall, only 3 to 15 % of a disease population are included.

Given that poor recruitment efficiency inflates costs and delays study timelines, participant recruitment in Switzerland urgently needs to be improved. Many solutions to this challenge exist. Firstly, increasing patient and citizen involvement in clinical trials has been shown to improve participation rates (12). Secondly, one aspect that deserves particular attention is improving the reputation of clinical research in society at large. The nature of news media is such that scandals – for instance in conjunction

with individual physicians, the pharmaceutical industry, or MedTech companies – are thrust in the limelight while gradual structural improvements such as patient involvement initiatives are often overlooked. Ideally, communication should emphasize the value of partnerships between scientists, patients, and citizens, the importance of clinical research for high-quality healthcare, and current initiatives in the field of patient involvement and empowerment in Switzerland. Constructive exchange between politicians, scientists, patients, and citizens is pivotal to addressing 21st century realities, and can counter the growing distrust towards authorities in society. Moreover, all clinical trials and observational studies should be routinely registered and lay-language summaries should be provided, as requested by the SNSF, to lower the barriers to patients and citizens being better informed and participating in clinical research.

During the Covid-19 pandemic, the importance of clinical research suddenly became publicly visible and was broadly discussed in the news media. Hospitals, medical institutions, and funding bodies shifted priorities very rapidly and made funds available for research, showing Switzerland's ability to transform culturally under pressure. This extraordinary situation should inspire the development of a "learning healthcare system" in which research and federated, interoperable research infrastructures directly contribute to improving the quality of healthcare and prevention, as well as to public health decision making. The Covid-19 crisis however also resulted in rushed, chaotic, and uncoordinated research efforts unlikely to produce high-quality results, partly due to the lack of planning and insufficient patient numbers. Politicians and scientists have moreover painfully overlooked patient engagement during the Covid-19 pandemic. These are typical phenomena that have limited the quality of clinical research and led to a waste of resources in the past.

To sum up, we identify a strong need for developing patient and citizen involvement to improve both clinical research quality and the societal reputation of clinical research.

4.2 Clinical research in the healthcare system

Since good care comes with – and from – good science, routinely integrating clinical research into patient care is pivotal to ensure efficacy and the best possible care and prevention. However, from the perspective of hospitals and related medical research institutions, clinical research is a complex issue. On the one hand, clinical research is an essential part of professional development and quality assurance of hospitals and related medical research institutions, and providing state-of-the-art healthcare makes them more attractive as care and training centers, thanks to clinical studies with new drugs and technologies or personalized medicine. On the other hand, however, investments in research infrastructures that support clinical research only have a medium- and long-term economic impact. Since hospitals are under increasing financial pressure, long-term investments are becoming more difficult and conflict with the support of infrastructures for clinical research and with providing protected research time/funding to hospital personnel.

Furthermore, physicians in training are insufficiently exposed to clinical research, and although the complexity of clinical research demands a high degree of collaboration and coordination, universities and university hospitals do not properly value efforts of physicians working on, for instance, clinical trial or data management platforms. Those who are exposed to clinical research should be given incentives to invest time in 'real-life'-data-driven clinical research instead of case reports or reviews.

Since universities mainly finance research funds, clear service-level agreements between hospitals and universities are needed for basic infrastructure and personnel costs (quality assurance, regulation). Project grants furthermore require realistic keys for chargeable costs (regulatory affairs, infrastructure use, data processing, data warehouse, data register and biobank costs), as well as clear budgeting and efficient accounting processes for these costs.

To develop a "learning healthcare system", a cultural change is necessary in the hospital and healthcare sector to ensure a tighter link between patient care, basic and clinical research, implementation science, and quality assurance. Thanks to this link, new insights can be gained from patient and citizen data (e.g., clinical outcome measures, biobank material, clinical studies) and can help to improve patient care in a timely, interactive, and iterative way. In this context, "trusted real-world data" from the Swiss healthcare system and communities often better reflects the local and national realities than data from international research.

4.3 Clinical research methods

A key step in increasing the quality of clinical research is the fostering of the entire spectrum of clinical trials and other clinical research methods, such as traditional randomized clinical trials, adaptive platform trials, hybrid trials, pragmatic trials, trials within cohorts,

emulated trials, early phase trials, and traditional observational studies. Prospective interventional trials remain the cornerstone of evidence-based patient care. Together, these methods form a continuum allowing researchers to cover the entire translation chain, from early development of new interventions, to implementation in routine clinical practice and continuous post-market evaluation.

Precision medicine combines genetic analysis with other molecular and cell biology techniques and imaging procedures to generate and analyze large amounts of data (big data). This makes it possible to obtain a much more precise diagnosis and to tailor treatment to the individual patient. The ability to molecularly characterize human diseases presents new challenges and opportunities for the design and analysis of clinical trials.

During the Covid-19 pandemic, however, the importance of, as well as the gaps in the continuum across the entire translation chain have become evident. In particular, the field of prospective trials has to be further developed in terms of funding, methodology, and regulatory environment. In addition, novel changes and challenges have appeared, including the development of medical apps, the new European medical devices regulations, and innovative study designs. Those chances and challenges can only be dealt with successfully in the context of constructive collaborations that transcend institutional, cantonal, and national borders.

4.4 Multidisciplinary clinical research teams

Considering the growing complexity and sophistication of today's clinical research in terms of methods, ethical and legal regulations, societal expectations, and costs, multidisciplinary collaborations are essential to guarantee quality and prevent research waste. Interprofessional collaboration, recognized as a pillar of healthcare quality and efficient management of resources (13), is increasingly considered of relevance for clinical research too. In clinical research, collaborations (understood as mutually beneficial and well-defined relationships between two or more people/organizations to achieve common goals) should involve different health researchers including nurses, pharmacists, and social, public-health, data, translational and implementation scientists. Establishing research careers for health professionals requires academic training, such as PhD programs in clinical research, that are not limited to physicians. Increasing the pool of academically trained health professionals from different backgrounds will improve process quality, data quality, and increase the range of possibile clinical study designs.

With the growing importance of (multidisciplinary and multicenter) teamwork comes the need for a broader definition of excellence. When evaluating applicants for grants or research positions, focusing on the number and journal-based metrics of their publications is an unjust simplification of clinical research reality. Being an active member of consortia, taking on responsibilities regarding data management or work packages, collaborating in large teams, teaching, mentoring, entrepreneurial endeavors, filing patents, and engaging in outreach activities are all aspects that can contribute to a researcher's excellence, and should be considered in evaluations. The SNSF has already taken an important step towards broadening the definition of excellence by signing the DORA declaration (San Fransisco Declaration of Research Assessment[3]) and has started to implement its recommendations.

Lastly, high-quality clinical research depends also on skills and know-how in terms of scientific integrity, gender equality, legal, and ethical standards. Of note, web-based tools can stimulate digital collaborations and foster multidisciplinary approaches in clinical research.

4.5 Researchers' environment

Clinician scientists can be considered as an endangered species since a clinical science career in Switzerland lacks clear advantages compared to the "physician-only" career path. The health crisis caused by the Covid-19 pandemic has reminded us of the acute need for clinician scientists able to conduct high-quality clinical trials and observational studies. Currently, the motivation of young researchers for clinical research is dampened by the following factors:

– Clinicians who engage in clinical research often do not receive adequate compensation or recognition. This can be explained by the sharp contrast between the drivers of the healthcare system, which are focused on improving patient care and often shaped by practical economic interests, and the drivers of clinical research, which are motivated primarily by knowledge gain and innovation. These driving forces sometimes pull in opposite directions: while hospital administrations focus on cost containment and quali-

3 www.snf.ch/en/theSNSF/research-policies/dora-declaration/Pages/default.aspx

ty of care, providing attractive career perspectives and sufficient funds for clinical researchers is not a priority. This phenomenon was described in 2002 (3) and still exists today;
– Young clinicians lack incentives to choose a career in clinical research. Protected time for research remains difficult to obtain, is financially less valued than clinical activities, and unequally divided between women and men. Reporting on how protected research time is effectively spent is often not required and dedicated funding instruments are still insufficient. Furthermore, combining patient care and research activities with childcare and family responsibilities is especially difficult, even more so as part-time jobs become increasingly popular. The lack of institutionalized mentoring to cope with challenges as a clinician scientist further reduces the attractiveness of such a career path;
– While more and more women choose medicine as a career, patriarchal structures in academic medicine, unequal distribution of care duties, and implicit biases in committees evaluating grant proposals and faculty position applications still cause women to disproportionally drop out of clinical research career paths (7,14).
– To overcome this impasse, university hospitals and related medical research institutions should value protected research time and develop intercalated training programs that allow clinicians to combine research and clinical training. The SIWF and medical specialty societies should strongly encourage and allocate time dedicated to clinical research, and universities could co-finance postgraduate clinical research training;
– Universities need to support proper training in clinical research methods and hospitals should reward dedicating time to research. MD-PhD programs need to be expanded and better funded (see, e.g., the Dutch model). Furthermore, clinical research PhD programs, open to various researcher profiles and health professionals, must be further developed and coordinated at a national level;
– Clinical research positions for junior profiles (PhD and MD-PhD students, postdocs), calls for grants, and procedures to acquire protected research time need to be openly publicized. Broad and open advertising of senior positions (tenure track, "Privatdozent*in") is also needed to allow interested clinicians to pursue a career path in clinical research;
– Motivating talented young doctors to choose a scientific career has become increasingly difficult. Exposing medical students at the pregraduate level and young MDs to clinical research and clinical-research-related skills can contribute to raising their interest in a research career;

Thus, to deal with the imminent challenges associated with the increasing complexity of today's medicine and to stimulate the development of innovative therapies and preventive interventions, investing in the career of young clinician scientists is of paramount importance. Proper funding for and recognition of protected research time, more funding and training options for MD-PhD and PhD students in patient-oriented research, and ample administrative support should provide incentives for the next generation of physicians and other health professionals to choose a career as clinician scientist.

4.6 Health data science

Realizing the promises of personalized health depends on the availability of large, high-quality, interoperable datasets that allow healthcare providers to optimize healthcare for individual patients – from prevention and diagnosis to treatment and rehabilitation – and for the entire population, for instance by enabling health promotion and early identification of disease risks. To harness the full potential of personalized health, the major challenges currently include:
– The development of tools to generate real world evidence (RWE) using observational data from multiple sources, and to deal with heterogeneous data with varying degrees of quality and fitness-for-purpose;
– The development of methods and tools for distributed analytics to keep data and their processing close to their source (hospital data warehouses and citizen health data clouds) to minimize the transfer of sensitive personal data;
– The development and enforcement of harmonized annotation methods, interoperability and quality criteria, aligned with international and industry standards, for data and metadata formats and patient core datasets as a basis for data query systems. In general, accessibility of data should be ensured (FAIR principles, Open Science, etc.). Such criteria are key to the harmonization and efficient linking and sharing of clinical information and biosamples, especially in multicenter studies, and are crucial for preventing study duplication and fostering societal trust;
– The national coordination and mapping of datastreams, multiomics platforms, cohorts, registries, and biobanks, as well as of bioinformatical, analytical, imaging and biomedical infrastructures to facilitate an efficient use of resources;
– High-quality clinical research requires the national availability of a large control population multiomics cohort and extensive national collaboration to efficiently use resources. This is currently only available for single-disease-oriented initiatives (e.g., cancer or rare diseases);

– Legal and practical questions regarding the introduction of electronic consent need to be answered concerning hospital software systems and the validity of electronic signatures.

A strong national coordination among the different stakeholders – based on a consensus about research priorities, responsibilities, and roles – is key for the development of data-driven clinical research and for effective representation of science in politics. Stakeholders include clinical and implementation science researchers and professionals from interdisciplinary clinical research networks (e.g., SCTO, CTU network, SPHN, SBP, SAKK, Swiss School of Public Health Plus (SSPH+)), and are crucial to conceptualize, perform, and analyze clinical studies, to guarantee access to high-quality data and samples, and to provide standards for data sharing and interoperability. Engaging existing discipline-centered collaboration networks in this endeavour will be crucial. This also includes a better interaction with regulatory bodies and healthcare authorities to improve and facilitate translation of clinical research into clinical practice. In many sectors of publicly funded research, such a superordinate coordination is still missing, which has led to redundancies in the clinical research system.

Beyond the data-related aspects themselves, the digital mechanisms mentioned above are also essential to build trust between patients, citizens, and research organizations: they offer ways to better inform participants in clinical research, dynamically gather and enforce consent, and enable more active participation and information sharing. University hospitals, related medical research institutions, and universities need to realize that safe data and trial infrastructures add value to both quality of clinical care and patient-oriented research. In addition, the development of nationwide networks and registries of clinical trial candidates can greatly improve patient recruitment (see chapter 4.1). A change in culture addressing the benefits of high-quality, data-driven research for health care provision in general, including models of care, future diagnostics, and treatments in hospitals and related medical research institutions is thus urgently needed: the healthcare system should provide strong incentives to support research, give clear financing strategies for research infrastructures in the hospitals and related medical research institutions, and refrain from including health data ownership and distribution as part of the institution's marketing strategy.

In conclusion, to properly use health data, data handling needs to be optimized and harmonized throughout institutions, and usage of existing valuable infrastructures should be made more efficient and coordinated at a national level. Funding agencies can play a structuring and enforcing role in this process.

4.7 Partnerships and national coordination

The translation of basic research findings from bench to bedside is a long and tedious process that faces several financial, regulatory, and ethical challenges (15,16). Strong partnerships between academic research institutions, translational platforms within or near hospitals, industry, patients, citizens, and politics are essential to improve the quality of clinical research on the long term, and to fill the knowledge and funding gaps that currently exist in the lifecycle of clinical research (Appendix 1, Fig. A3). For partnerships between stakeholders to be successful, collaborations need to be based on a pragmatic framework regarding ownership, intellectual property, conflicts of interest, publication rights, and funding allocation. This cooperation also needs to be achieved at a national level, requiring top-down decisions. In addition, exposure of clinical research trainees to data from industry, and encouraging private companies to create internships and temporary positions for young clinical researchers could be mutually beneficial when aiming towards fostering partnerships.

Given the small size of the country, factors limiting the development of high-quality clinical research in Switzerland include the involvement of necessary experts and stakeholders, reaching the critical mass of patients, and accessing nationally available infrastructures. Thus, solid partnerships between academic, societal, political, and industry actors are essential to improve Switzerland's international position in clinical research rankings. These can be successful only if harmonized regulations are defined at a national level and adhered to by all involved actors.

Regarding publicly funded research institutions, Switzerland's federalist tradition, fragmented cantonal legal frameworks, multilingualism, and often insufficient communication and collaboration between institutions pose significant hurdles to clinical research. This leads to redundancies, complexities, and resource waste. The use of existing infrastructures, such as CTUs, SAKK coordinating center, and data and biobank infrastructures, should become mandatory for publicly funded research. The regulatory and legal hurdles that come with sharing such infrastructures between institutions and over cantonal borders need to be identified and smoothed out. Moreover, to efficiently use the currently existing structures, a national platform is required to enable collaboration and coordination, as well as clear and efficient processes, responsibilities, and decision mechanisms. These coordination efforts are often underestimated.

The nationally coordinated, decentralized ethics committees in charge of the evaluation and approval of clinical trials ("lead committee" model) have improved ethics evaluations for multicenter studies, but cannot be a model case for other aspects of multicenter clinical research projects. Centralized solutions, or even a one-stop shop for regulatory and ethical approvals, should be put in place instead. The ongoing partial revision of the ordinances attached to the HRA which should come into force in the second half of 2021, is expected to further improve the harmonization of electronic forms of informed consent as well as submission, and approval processes (17). Lastly, the facilitation of data sharing, not only between institutions at the national level but also across Europe and at a global scale, is essential for Switzerland to be competitive on an international level. These efforts must comply with legal and ethical data protection rules while accommodating the request for open data access.

Since research fields can develop faster than the law can be adapted, high-quality clinical research depends on a legal and ethical framework that is strong in its basic features, but flexible and pragmatic in its applications. The challenge is to dynamically define conditions of use of emerging technologies, such as artificial intelligence and the sharing of data or biobank material. Such a framework needs to handle the basic rights and responsibilities of all parties involved in data/sample use, ownership, publications, intellectual property rights, and liability, thereby facilitating multistakeholder clinical research. Setting up such a framework harmonizing the legal, regulatory, and ethical aspects at a national level is key to improving the quality of clinical research. This is particularly important in a post-Covid-19 society, where the need for pragmatic, coordinated, and multicenter research is clearly visible.

5. Goals, recommendations and measures

To make Switzerland a leading country in clinical research that reaches high impact in patient care, the following key goals and main recommendations with accompanying measures are formulated based on chapter 4. As several measures depend on reinforced coordination among stakeholders at a national level, the creation of the proposed National Coordination Platform for Clinical Research is presented first.

Goal 1: Create a national coordination platform ("National Coordination for Clinical Research")

Recommendations

1. A national coordination platform must be set up by SERI to ensure overall strategic priorities and a clear distribution of tasks and responsibilities among stakeholders in clinical research.

Measures

a) Create a national platform to increase the coordination of publicly funded stakeholders in clinical research, in alignment with the shared vision presented in the white paper. The platform would be mandated by SERI with the following tasks:
   1. Reduction of redundancies through a clear distribution of tasks and responsibilities among stakeholders;
   2. Definition of overarching national priorities for publicly funded clinical research;
   3. Elaboration of a label for institutions involved in clinical research (definition of minimal requirements to fulfil to be recognized as an institution favorable to clinical research);
   4. National coordination of education and career support in clinical research.

   The platform would prepare consolidated decision-making bases for SERI, who would issue specific mandates to those institutions for which it is responsible for the implementation of the measures.

   In the build-up phase, the platform would be composed of a core group of key national stakeholders of publicly funded clinical research (governmental and institutional stakeholders, users, clinical and health researchers). The initial composition of the platform should be specified in the SERI mandate. In later stages, the platform would have the option to include further relevant actors and to adjust its composition according to its tasks.

b) Make adherence to the requirements and standards defined by the National Coordination Platform a prerequisite for service-level agreements of SERI with all publicly funded academic actors;
c) Make it mandatory for all publicly supported clinical research institutions to invest part of their funding to support national coordination and alignment efforts.

Goal 2: Establish strong partnerships with society, citizens, and patients

Recommendations

1. Public campaigns must be created and funded to foster a culture of social responsibility for participation in clinical research and secure personal health data sharing;
2. Citizens and patients must be involved in strategic discussions and initiatives pertinent to clinical research[1];
3. Current efforts to create patient panels and a national framework for Patient and Public Involvement (PPI)[2] must be coordinated and promoted.

Measures

a) Set up shared public campaigns;
b) Map and monitor citizen and patient involvement activities in clinical research;
c) Perform a public survey to measure public perception of clinical research and serve as the baseline to measure the effectiveness of patient-public involvement activities (now and in 4 years), taking experiences from the Covid-19 pandemic into account.

Goal 3: Promote a healthcare system that systematically integrates clinical research: Good care comes with – and from – good science

Recommendations

1. Clinical research has to be part of patient care wherever the latter takes place;
2. Implementation science needs to be promoted to ensure integration of new effective interventions into routine care;
3. Universities and medical faculties must value collaborative data sharing and open access efforts in academic career advancement;
4. All patients should be offered the chance to participate in ongoing studies and to share health data.

Measures

a) Develop a label for institutions involved in clinical research (university and cantonal hospitals, other institutions) based on stringent criteria defined by a specific task force[3], recognizing environments favorable to clinical research and attractive to clinical and health researchers. In the long term, this label should affect the share of public funding allocated to institutions;
b) Perform a regular, random review of clinical studies being completed, reported, and published as planned.

Goal 4: Invest in the development of innovative and dynamic clinical research approaches and technologies

Recommendations

1. Clinical research methods need to be continuously improved;
2. Research on research methodology is essential for the future of clinical research and must be fostered.

Measures

a) Formally include research-on-research and implementation science in public calls for research proposals;
b) Assess and monitor research on research methodology;

Goal 5: Strengthen translational, innovative, and integrated clinical research teams

Recommendations

1. Criteria used (e.g., by universities and research funders) to assess excellence in clinical research must be revised (taking into consideration also the DORA declaration);
2. Multidisciplinary training, career tracks, and academic appointments must be increased and offered to health professionals[4] and other researchers[5] involved in clinical research;
3. Institutions involved in clinical research must ensure that teams are equipped with a variety of skills[6] and adhere to the highest ethical standards;
4. Academy-industry/corporate partnerships must be clearly governed at a national level.

Measures

a) Revise the current criteria by which medical faculties measure excellence in clinical research, in collaboration with the SNSF; include unmet medical needs as an evaluation criterion for clinical research grants, beside innovation and novelty;
b) Perform a regular review of academic appointments in clinical research;
c) Create a national policy to facilitate and regulate collaborations with industry.

Goal 6: Create an environment that is attractive to clinical and health researchers at all career levels

Recommendations

1. Exposure to clinical research must be increased at pre- and postgraduate level;
2. Hospitals, related medical research institutions, and universities must commit to and support protected research time at all career stages and for all health professionals, with attention to gender equality[7]. They must, together with the SNSF, contribute to its appropriate funding;
3. SIWF and medical specialty societies must enhance the recognition of clinical research and integrate it in their requirements for specialty titles;
4. MD-PhD programs as well as PhD programs for clinical researchers and health professionals involved in clinical research must be properly funded and coordinated at a national level.

Measures

a) Map existing activities and review the effective funding for protected time for research offered by university and cantonal hospitals, as well as by related medical research institutions;
b) Based on the results of the mapping, complete the offer with dedicated instruments where funding is insufficient (set up a large-scale national funding scheme for clinical researchers at pre- and postgraduate level);
c) Review the recognition of clinical research in medical curricula, including curricula for "clinical scientists";
d) Coordinate (or create) national MD-PhD and PhD programs in clinical research for physicians, nurses, and other health professionals.

Goal 7: Reduce the complexity of regulatory and data-related processes

Recommendations

1. Clinical research must rapidly translate into patient care via clearly coordinated value chains linking discovery, hypothesis testing, validation, and implementation;
2. Data interoperability and sharing between multicenter studies must be facilitated through collection of data according to FAIR principles and through a nationwide, secure IT environment respecting the legal and regulatory requirements.

Measures

a) Harmonize ethics approval processes at a national level[8];
b) Urgently adapt and harmonize at a national level the legal and regulatory frameworks for the use and sharing of health data[9]; create a legal framework for e-consent, and a unique patient and research citizen ID according to the recommendations of the SAMS-SPHN report 2016–2019 (16);
c) Establish interoperability of infrastructures, metadata, and data flows between national research stakeholders (see horizontal integration in SAMS-SPHN report (18)) and within institutions, including translational science (vertical integration); ensure interoperability with international standards;
d) Create a sustainable, long-term, independent structure for the national coordination of research health data by 2024 (successor of the DCC), including technical concept, metadata and data governance, data access policy and a long-term business plan;
e) Make adherence to the standards and guidelines defined by the national coordination structure for research health data mandatory for all publicly funded clinical research projects (including by the SNSF); Ensure that resulting additional costs are eligible in project budgets.

Notes

1 e.g., in research agendas and ethics committees
2 e.g., hospitals, primary care centers, Swiss Clinical Trial Organization (SCTO), Swiss Group for Clinical Cancer Research (SAKK), Swiss Biobanking Platform (SBP), Swiss Personalized Health Network (SPHN), corporate world
3 regarding a set of predefined and agreed-on performance indicators, covering, e.g., data sharing, professional support, mentoring, and incentives to engage in clinical research
4 e.g., physicians, nurses, and pharmacists
5 e.g., basic, translational, data, public health, and social scientists
6 e.g., methodology, data science, statistics, IT infrastructures, business and entrepreneurship, leadership
7 see e.g., the collaborative Divmed project, funded by swissuniversities, that promotes diversity and equal opportunities for junior academic leaders in five medical faculties (https://www.divmed.uzh.ch)
8 regarding consent management, including e-consent solutions (e.g., swissethics, unimedsuisse), data standards and semantics (e.g., SPHN), and hospital IT strategy, IT security strategy, data protection and data deidentification strategies (e.g., SPHN, hospitals)
9 e.g., SPHN, SBP, institutions, cantons

6. Roadmap

In chapter 5 of this white paper, seven goals with accompanying recommendations and measures have been formulated, which the working group regards as appropriate and necessary to make Switzerland an international leader in high-quality clinical research that is impactful for patient care. The following roadmap offers suggestions concerning the various steps and actors involved in the implementation of each of these measures. Here, the following points should be borne in mind:

– As the number of individual measures required is substantial, the roadmap details those, in particular, whose implementation can be directly or indirectly influenced by stakeholders represented in the working group and by the federal instance which mandated the elaboration of the white paper. This does not mean that other measures are of less importance.
– All public actors of clinical research are invited to define for themselves and to implement those measures which are relevant for them and which support the implementation of the shared vision formulated in the white paper.

Goal 1: Create a national coordination platform ("National Coordination for Clinical Research")

Recommendations	Measures	Who?	When?
1. A national coordination platform must be set up by SERI to ensure overall strategic priorities and a clear distribution of tasks and responsibilities among stakeholders in clinical research.	a) Create a national platform to increase the coordination of publicly funded stakeholders in clinical research, in alignment with the shared vision presented in the White Paper. The platform would be mandated by SERI with the following tasks: 1) reduction of redundancies through a clear distribution of tasks and responsibilities among stakeholders; 2) definition of overarching national priorities for publicly funded clinical research; 3) elaboration of a label for institutions involved in clinical research (definition of minimal requirements to fulfil to be recognized as an institution favorable to clinical research); and 4) national coordination of education and career support in clinical research. The platform would prepare consolidated decision-making bases for SERI, who would issue specific mandates to those institutions for which it is responsible for the implementation of the measures. In the build-up phase, the platform would be composed of a core group of key national stakeholders of publicly funded clinical research (governmental and institutional stakeholders, users, clinical and health researchers). The initial composition of the platform should be specified in the SERI mandate. In later stages, the platform would have the option to include further relevant actors and to adjust its composition to its tasks.	**Mandate:** SERI (lead federal instance) **National coordination platform:** multistakeholder body **Coordinating office:** SAMS	**Build-up:** End 2021
	b) Make adherence to the requirements and standards defined by the National Coordination Platform a prerequisite for service-level agreements of SERI with all publicly funded actors involved in clinical research.	SERI	
	c) Make it mandatory for all publicly supported clinical research institutions to invest part of their funding to support national coordination and alignment efforts.	SERI, with cantons and swissuniversities	

Goal 2: Establish strong partnerships with society, citizens, and patients

Recommendations	Measures	Who?	When?
1. Public campaigns must be created and funded to foster a culture of social responsibility for participation in clinical research and secure personal health data sharing.	a) Set up shared public campaigns.	**Trigger:** National Coordination Platform **Modular campaigns:** e.g. SCTO, SAKK, SSPH+, public health CH, pro-salute	2022–open
2. Citizens and patients must be involved in strategic discussions and initiatives pertinent to clinical research[4].	b) Map and monitor citizen and patient involvement activities in clinical research	SCTO (coordination of existing multistakeholder WG[5].), SNSF	2022–3
3. Current efforts to create patient panels and a national framework for Patient and Public Involvement (PPI)[6] must be coordinated and promoted.	c) Perform a public survey to measure public perception of clinical research and serve as the baseline to measure the effectiveness of patient-public involvement activities (now and in 4 years), taking experiences from the Covid-19 pandemic into account.	Multistakeholder WG coordinated by SCTO **First addressee:** SSPH+ (via corona immunitas study[7]?)	2022–3

Goal 3: Promote a healthcare system that systematically integrates clinical research: Good care comes with – and from – good science

Recommendations	Measures	Who?	When?
1. Clinical research has to be part of patient care wherever the latter takes place ("good care comes with – and from – good science")	a) Develop a label for institutions involved in clinical research (university and cantonal hospitals, other institutions) based on stringent criteria defined by a specific task force[8], recognizing environments favorable to clinical research and attractive to clinical and health researchers. In the long term, this label should affect the share of public funding allocated to institutions.	**Specific task force** (to start), then National Coordination Platform with unimedsuisse	2022–open
	b) Perform a regular, random review of clinical studies being completed, reported, and published as planned.	SCTO, SAKK	2022–open
2. Implementation science needs to be promoted to ensure integration of new effective interventions into routine care.		Medical faculties, hospitals	2022–4
3. Universities and medical faculties must value collaborative data sharing and open access efforts in academic career advancement.		Medical faculties, universities	2022–open
4. All patients should be offered the chance to participate in ongoing studies and to share health data.		Hospitals, medical faculties	2022–open

4 e.g., in research agendas and ethics committees

5 multistakeholder working group on Patient and Public Involvement Hub, led by SCTO, co-funded by SNSF and SPHN

6 e.g., hospitals, primary care centers, SCTO, SAKK, SBP, SPHN, corporate world

7 www.corona-immunitas.ch

8 regarding a set of predefined and agreed-on performance indicators, covering, e.g., data sharing, professional support, mentoring and incentives to engage in clinical research

Goal 4: Invest in the development of innovative and dynamic clinical research approaches and technologies

Recommendations	Measures	Who?	When?
1. Clinical-research methods need to be continuously improved.	a) Formally include research-on-research and implementation science in public calls for research proposals.	SCTO (STEAM group[9]) and SAKK, with SNSF	2022–3
2. Research on research methodology is essential for the future of clinical research and must be fostered.	b) Assess and monitor research on research methodology.	SCTO with SNSF	2022–4

Goal 5: Strengthen translational, innovative, and integrated clinical research teams

Recommendations	Measures	Who?	When?
1. Criteria used to assess excellence in clinical research must be revised (taking into consideration also the DORA declaration).	a) Revise the current criteria by which medical faculties measure excellence in clinical research, in collaboration with the SNSF; include unmet medical needs as evaluation criterion for clinical research grants, beside innovation and novelty.	Collège des Doyens, SNSF, industry representatives	2022–3
2. Multidisciplinary training, career tracks, and academic appointments must be increased and offered to health professionals[10] and other researchers[11] involved in clinical research.	b) Perform a regular review of academic appointments in clinical research.	College des Doyens, hospitals	2022–3
3. Institutions involved in clinical research must ensure that teams are equipped with a variety of skills[12] and adhere to the highest ethical standards.			
4. Academy-industry/corporate partnerships must be clearly governed at a national level.	c) Create a national policy to facilitate and regulate collaborations with industry.	SPHN, SAKK	2021

Goal 6: Create an environment that is attractive to clinical and health researchers at all career levels

Recommendations	Measures	Who?	When?
1. Exposure to clinical research must be increased at pre- and postgraduate level.	a) Map existing activities and review the effective funding for protected time for research offered by university and cantonal hospitals, as well as by related medical research institutions.	SAMS with SCTO (update of 2019 analysis (6))	2022
2. Hospitals, related medical research institutions, and universities must commit to and support protected research time at all career stages and for all health professionals, with attention to gender equality. They must, together with the SNSF, contribute to its appropriate funding.	b) Based on the results of the mapping, complete the offer with dedicated instruments where funding is insufficient (set up a large-scale national funding scheme for clinical researchers at pre- and postgraduate level).	**Trigger:** National Coordination Platform **Addressees:** swissuniversities, SNSF, hospitals, medical faculties	2022–open
3. SIWF and medical specialty societies must enhance the recognition of clinical research and integrate it in their requirements for specialty titles.	c) Review the recognition of clinical research in medical curricula, including curricula for "clinical scientists".	SIWF, SERI (law on medical professions), medical faculties	2022–open
4. MD-PhD programs as well as PhD programs for clinical researchers and health professionals involved in clinical research must be properly funded and coordinated at a national level.	d) Coordinate (or create) national MD-PhD and PhD programs in clinical research for physicians, nurses, and other health professionals.	SAMS, SNSF, SCTO, swissuniversities, UAS	2022–3

9 www.scto.ch/en/network/research-on-research.html

10 e.g., physicians, nurses, pharmacists

11 e.g., basic, translational, data, basic, public health, social scientists

12 methodology, data science, statistics, IT infrastructures, business and entrepreneurship, leadership

Goal 7: Reduce the complexity of regulatory and data-related processes

Recommendations	Measures	Who?	When?
1. Clinical research must rapidly translate into patient care via clearly coordinated value chains linking discovery, hypothesis testing, validation and implementation.	a) Harmonize ethics approval processes at a national level[13].	swissethics, National Coordination Platform	2022–4
2. Data interoperability and sharing between multicenter studies must be facilitated through collection of data according to FAIR principles and through a nationwide, secure IT environment respecting the legal and regulatory requirements.	b) Urgently adapt and harmonize at a national level the legal and regulatory frameworks for the use and sharing of health data[14]; create a legal framework for e-consent, and a unique patient and research citizen ID according to the recommendations of the SAMS-SPHN report 2016–2019 (18).	SPHN, with BFS (transferred as of 2024 to the long-term structure replacing the DCC)	2022–3
	c) Establish interoperability of infrastructures, metadata, and data flows between national research stakeholders (see horizontal integration in SAMS-SPHN report (18)) and within institutions, including translational science (vertical integration); ensure interoperability with international standards.	SPHN	2022–4
	d) Create a sustainable, long-term, independent structure for the national coordination of research health data (successor of the DCC) by 2024, including technical concept, metadata and data governance, data access policy and long-term business plan.	SPHN	2022–4
	e) Make adherence to the guidelines and standards defined by the national structure for the coordination of research health data mandatory for all publicly funded clinical research projects (including by the SNSF); Ensure that resulting additional costs are eligible in project budgets.	SERI, SNSF	2024

13 regarding consent management, including e-consent solutions (e.g., swissethics, unimedsuisse), data standards and semantics (e.g., SPHN), and hospital IT strategy, IT security strategy, data protection and data deidentification strategies (e.g., SPHN, hospitals)

14 e.g., SPHN, SBP, institutions, cantons

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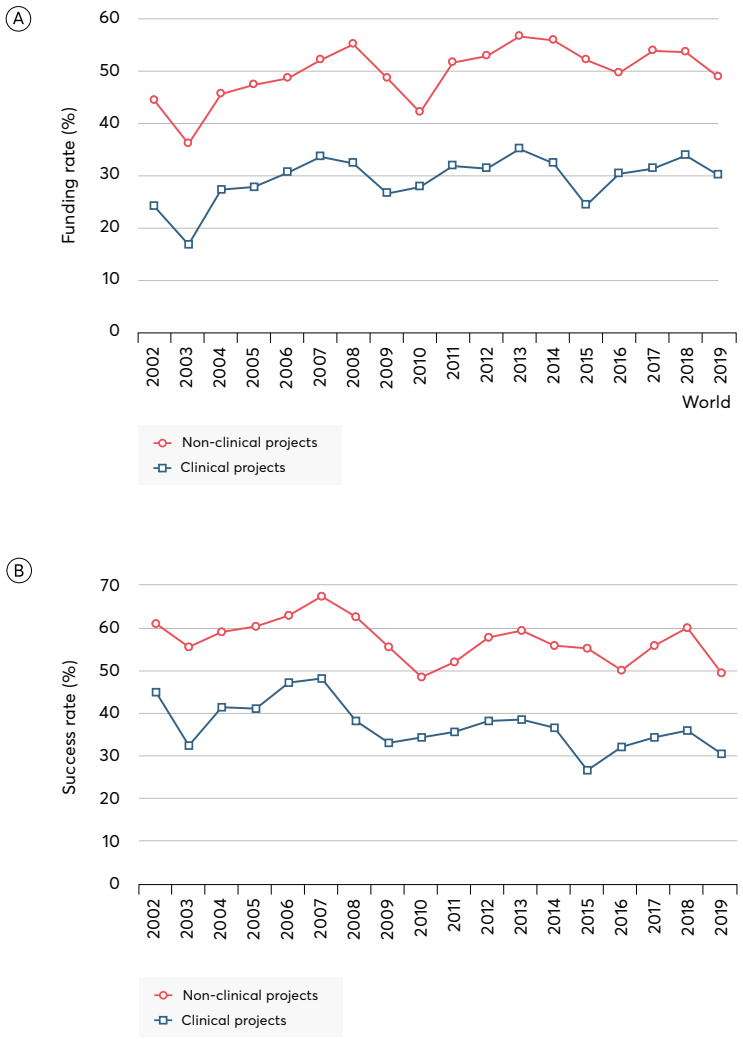
Appendix 1: Performance of clinical research in Switzerland since 2002

Figure A1: Evolution of Switzerland's impact by research field in international comparison.
The analysis of the evolution of publication impact by research field shows that Switzerland is performing very well overall (Fig. A1a and A1b). While until the early 1980s, it exceeded the world average in only three fields, it now does so in almost all areas. This is also true for Clinical Medicine, for which the impact has lain above the world average since the early 2000s.
Impact (relative citation indicator) is calculated by the number of citations received per publication. As the number of citations depends on publication and citation practices, which can vary considerably according to the field of research, a standardized indicator is needed. The absolute number of citations received by publications is set against the world average of citations per publication for each research field. This relative indicator is then standardized on a scale of 0 to 200, where 100 represents the world average. Until 2016, impact data were calculated by SERI based on the data present in three "simple" databases (SCI, SSCI, and A&HCI). As of 2016, data have been collected from the "expanded" version of these databases and from an additional one (ESCI). This prevents an aggregation of data over the entire period.

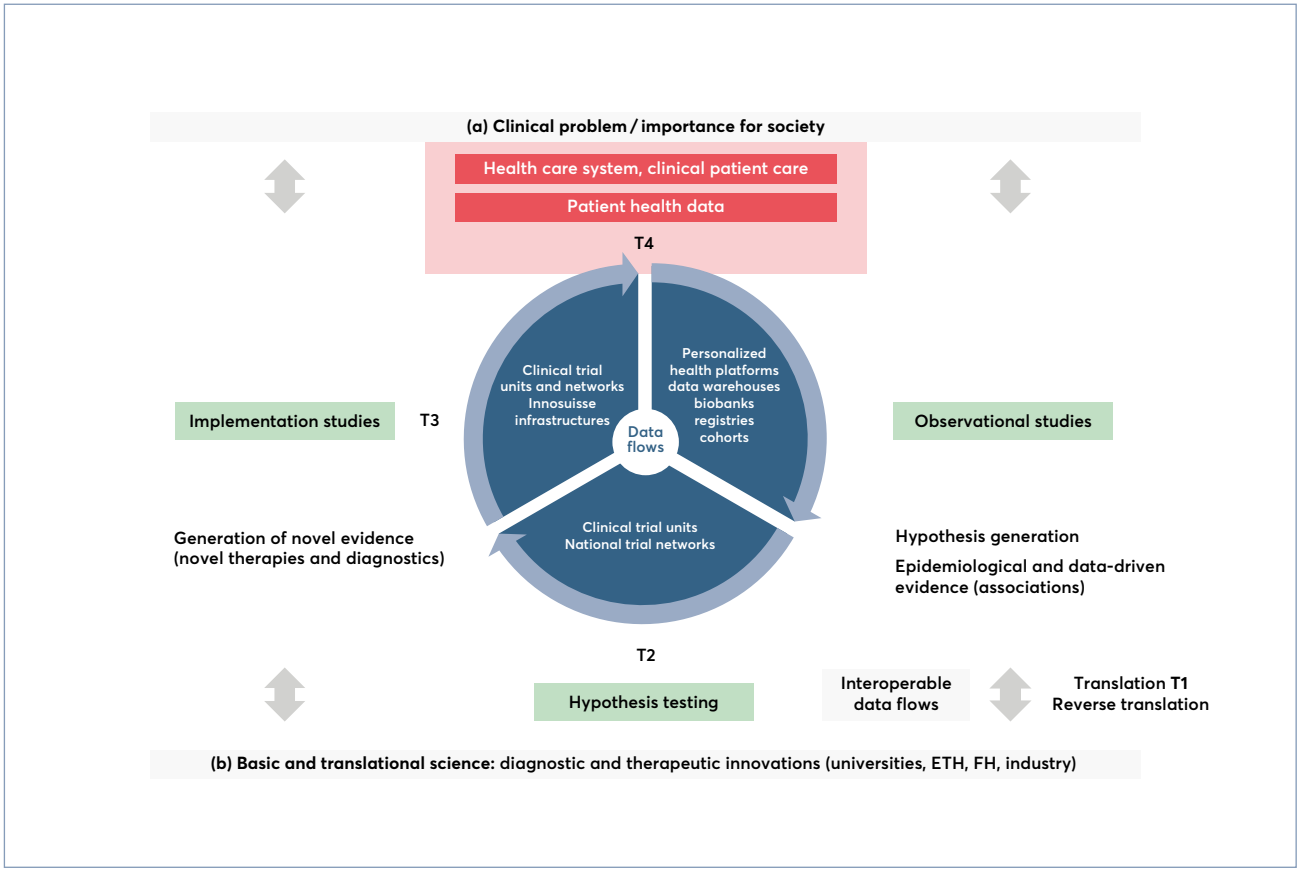
Source: Graphics provided upon request by SERI, 2020, Clarivate Analytics (SCIE/SSCIE/A&HCI/ESCI).

Figure A2: Evolution of the funding and success rate of clinical research proposals at the SNSF (project funding scheme, Biology and Medicine Division).
A, Funding rate (funded amount versus requested amount) of clinical versus non-clinical research proposals. B, Success rate (funded proposals versus submitted proposals) of clinical versus non-clinical research proposals. In the project funding instrument in the SNSF Biology and Medicine Division, the funding and success rate of clinical research proposals has been 20 % lower than that of non-clinical research proposals during the period 2002–2019.



Source: Graphics provided upon request by the SNSF, Biology and Medicine Division, 2020.

Figure A3: Schematic model of the role of research infrastructures in the life cycle of clinical research with its 4 translation phases.
T1, translation to humans; T2, translation to patients; T3, translation to clinical practice; T4 translation to population health. Due to rapid technical advances, the traditional borders between the different disciplines are dissolving. Publicly funded research infrastructures and large data networks such as registries, cohorts, routine care, and hospital databases increasingly foster a continuum of different study designs and approaches needed for high-quality clinical research.



Appendix 2: List of experts involved in the elaboration of the white paper

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Appendix 3: Present state: main academic actors (details)

1. Swiss National Science Foundation (SNSF)

Main achievements

Over the period 2002–2019, the SNSF has supported the field of clinical research with a total amount of over 1,000 Mio CHF. This includes the grants awarded in clinical disciplines from all regular project, career, and program funding instruments, research infrastructures as well as special programs designated for clinical research. From 2002–2019, the SNSF has supported clinical research through a large palette of funding instruments and initiatives. These include:

- Grants for multicentric, population-based, and disease-oriented studies with a longitudinal design (longitudinal studies);
- Financing the development (until 2014) of Clinical Trial Units (CTUs) at the five university hospitals and at the cantonal hospital St. Gallen to promote patient-oriented clinical research, including support in the planning and implementation of innovative clinical studies. CTUs are still financed via project funding;
- The special program "Universitäre Medizin";
- Support of biomedically oriented National Research Programmes (NRP), including the NRP "Smarter Health Care" with the aim of promoting innovative health services research in Switzerland and building up accessible, high-quality, and usable health data;
- The introduction of the Investigator Initiated Clinical Trials (IICT) funding scheme in 2015 to support clinical studies addressing important unmet medical and societal needs outside of industry focus;
- Partial financing of the Swiss Clinical Trial Organisation (SCTO), a cooperation platform for patient-oriented clinical research in Switzerland;
- Development and financing of the Swiss Biobanking Platform (SBP) which serves as a national coordination centre and reference platform for biobanking, providing services for the translational, preclinical, and clinical biomedical researchers;
- Support of Swiss researchers in EU consortium projects (ERA-Net ERare, JP Neurodegeneration, ERA-Net Neuron, EJP Rare Diseases);
- Promotion of innovation and technology transfer in the biomedical field (Bridge program), of interdisciplinary research (Sinergia) and support of biomedically oriented National Centres of Competence in Research (NCCRs).

Regarding the promotion of junior medical researchers, the SNSF has increased its support to the National MD-PhD program (a joint program with the SAMS and partner funders), awarding 2 Mio CHF per year since 2009. Most grantees are however involved in biomedical rather than patient-oriented research. Medical researchers have further been supported through the regular SNSF Career instruments (Mobility fellowships, Ambizione-SCORE, Eccellenza, PRIMA). Women who had to interrupt or reduce their research activities due to family commitments have been specifically supported via the Marie Heim-Vögtlin (until 2016) and PRIMA (as of 2017) instruments. In 2015, the SNSF launched the initiative "Protected Research Time for Clinicians" (PRTC) as incentive for institutions to develop their own protected time program; it aims at allowing early-career clinicians to dedicate at least 30 % of their working time to their research project funded by the SNSF. Lastly, to make the assessment of research output fairer, the SNSF has signed the DORA declaration and started the step-by-step implementation of its recommendations: impact factors are excluded from evaluation in career funding, and in a pilot project in the Biology and Medicine Division, applicants have to use a standardized CV format, presenting their most important achievements instead of only listing publications.

2. Swiss Clinical Trial Organisation (SCTO)

Main achievements

The founding members of the SCTO are the five Swiss university hospitals, the cantonal hospital St. Gallen, SAMS, and the representatives of the medical faculties (Collège des Doyens) at the Swiss universities. The Ente Ospedaliero Cantonale (EOC) has been a full member since 2019.

In 2019 the CTU Network was funded by a yearly federal contribution of 2.4 Mio CHF, matched by significantly higher contributions of the hosting hospitals. Among the supported clinical research activities are classical prospective interventional trials Phase I-IV (35 %), prospective observational cohorts and registries, and research with routinely collected data and samples (39 %). Support is provided in accordance with harmonized quality standards jointly developed by the CTUs and the Swiss Group for Clinical Cancer Research (SAKK) (see 3.1.5). All CTUs have committed to aligning their management systems to applicable national and international regulatory requirements.

Furthermore, the SCTO has built up national platforms serving as pools of expertise in the above-mentioned fields. Each platform consists of a team of experts from member institutions related to one key aspect of clinical research.

The SCTO provides education and continuous training in clinical research beyond ethics and good clinical practice (e.g., CAS, MAS, PhD in clinical research) in collaboration with epidemiology and academic public health institutions federated under the coordination of the Swiss School of Public Health (SSPH+). A 2017 survey on the impact of the CTUs on the value of clinical research in Switzerland concluded that the CTU Network had positively influenced the quality of academic clinical research in the country.

The SCTO further partners with many international initiatives such as the European Patients' Academy on Therapeutic Innovation (EUPATI) and is an observer in the European Clinical Research Infrastructures Network (ECRIN-ERIC).

The SCTO coordinates and leads roundtables and taskforces with relevant authorities (e.g., swissmedic, swissethics, FOPH) and coordinates the Federal Office of Public Health' (FOPH) roadmap for developing the next generation of clinical researchers (6). Together with the SAMS and unimedsuisse, the SCTO is developing the Swiss Portal for Clinical Researchers, a national web portal for career support and education. Overall, the SCTO builds up resources to lobby for clinical research and to strengthen its public voice with a large spectrum of activities.

3. Swiss Personalized Health Network (SPHN)

Main achievements

The founding of the SPHN is partly motivated by the notion that the IT infrastructures on which health data are processed need to fulfil stringent data and privacy protection and information security requirements. Such infrastructures enable the creation of large, harmonized patient data sets to allow scientists to use multiomics technologies to contribute to personalized health research or precision medicine.

The Infrastructure development projects and Driver projects are supported with 24 Mio CHF. All SPHN funds have to be matched by host institutions. The Infrastructure development projects are dedicated to developing and testing new technologies, methods, and infrastructures at single or joint sites, to be made available to other institutions after proof of concept. In the Driver projects, the infrastructures and interoperability are tested for multisite research in a specific area or pathology. Each Driver project typically involves multiple "data providers" (predominantly university hospitals, but also universities, research insitutions, and analytic platforms) as well as teams of "data recipients" who analyze the data. The data are securely transferred via the BioMedIT network led by the Personalized Health Informatics Group of the Swiss Institute of Bioinformatics (SIB).

The Infrastructure implementation projects with the five university hospitals (Collaboration Agreements, 15 Mio) and the Data Coordination Center (DCC) are complimentary to the BioMedIT project (funded with 2.8 and 18 Mio CHF, respectively). Together, the DCC and the Infrastructure implementation projects aim at building a national federated network enabling secure data transfer and a distributed federated query system in university hospitals to identify encoded health data of groups of specified patients (e.g., with a given clinical diagnosis).

The SPHN has furthermore contributed to the creation of a series of technical, ethical, and health data research standards and agreements, such as an ethical framework (including data sharing principles, guidance on the return of actionable clinical findings, and a template for a data transfer and use agreement), an infrastructure roadmap (BioMedIT network), an IT information security policy, a data semantic interoperability strategy and a hospital IT strategy.

The SPHN stringently coordinates its efforts with partner networks such as PHRT, SBP, SCTO, and patient and citizen organizations, and initiated a series of multi-stakeholder working groups tasked with the following specific mandates: development of 1) a concept for a Swiss federated genomics network; 2) a concept for a Swiss federated metabolomics/proteomics network; 3) a data lifecycle management strategy/policy; 4) a harmonized Swiss cohort and registry strategy ensuring data interoperability; and 5) principles, standards, and the development of guidelines for collaboration with industry. The SPHN also contributes to working groups developing a concept for patient and citizen involvement (lead SCTO with patient organizations) as well as intellectual property guidelines (lead SBP).

4. Swiss Biobanking Platform (SBP)

Main achievements

Founded in 2014, with a budget of 3.2 Mio CHF for its initial funding period 2015–2018, several important

achievements were realized, such as establishing connections to the BBMR-ERIC and the development of recommendations for biobanking activities. The SBP has offered independent audits on quality and governance issues to facilitate interoperability and harmonization of biobanks, and has supported the development of biobanks with a specific toolbox allowing biobanks to reach higher quality standards. The toolbox comprises several services: 1) Biobank SQAN, the biobank Solution for Quality Assessment and Normalization, a web-based tool that helps biobanks to comply to the minimal requirements regarding governance, process, and quality management; 2) development of MTA templates; 3) Documents library, which provides different types of documents, policies, procedures, templates, and datasets, covering biobank governance, quality, and interoperability. The SBP also collaborates with the SCTO and SPHN, and with other actors in the field such as Swissethics.

During the funding period 2019–2020, the SBP focused on four major issues: 1) consolidating the SBP structure and management, strengthening its central role in the Swiss human and nonhuman biobanking community, and as the national node of BBMRI-ERIC; 2) further developing the tool box (SBP NExT, the SBP network exploration tool to visualize the Swiss biobank network); 3) developing guidelines to facilitate access to biobanking samples by establishing a Swiss biospecimen catalogue at the sample level in collaboration with SPHN; 4) driving the quality management of biobanking activities.

5. Swiss Group for Clinical Cancer Research (SAKK)

Main achievements

To optimize patient recruitment for clinical research, the SAKK network comprises 15 non-university centers in addition to university hospitals. It has recently launched the "regional networks" pilot project for the period 2019–2020, which aims to strengthen existing regional hospital networks by involving smaller hospitals in the conduct of clinical trials so that even cancer patients in the periphery can be treated in a clinical study (ensuring fair access to new therapies regardless of place of treatment). Seven SAKK members within a total of 22 networked hospitals are participating in the project.

SAKK is a member of the SPHN-initiated Swiss Personalized Oncology (SPO) project, which aims to harmonize clinical and laboratory data of cancer patients to make them accessible and exchangeable for oncology research projects.

To facilitate national and international collaborations, SAKK strives to establish the infrastructure to integrate all SAKK members and their networks into data projects. In 2019, it launched the Swiss Centralized Oncology Real Word Evidence Data (SCORED) platform concept to enable all network members to provide data from everyday clinical practice. The platform should also allow any researcher to use these data to answer research questions. In close cooperation with SPHN/SPO, data collection processes will be harmonized accross Switzerland, technical requirements for all hospitals will be established, and guidelines will be developed to ensure FAIR (Findable, Accessible, Interoperable, Reusable) access to the data.

One of SAKK's initiatives in supporting early career clinical researchers is the Young Oncology Academy, a mentoring program for oncology residents at the beginning of their medical career who would like to contribute to clinical and translational research, with a focus on cancer medicine, hematology, radio-oncology, urology, gynecology, or dermatology, and training in clinical trial development, management, execution, and publication.

With the goal of conducting patient-centric trials and actively involving patients at each stage of the clinical research process, SAKK founded the Patient Advisory Board in 2015. This aims to understand the experiences and needs of cancer patients and their relatives and to better take their needs into account. The Patient Advisory Board also ensures that lay persons can understand clinical trial documents, an important element in the recruitment of study participants. To stimulate the exchange and foster the trust between science and the public, SAKK has also formulated a publication guideline stating that all results, including negative and inconclusive ones, should be published or made publicly available.

Since the financial forcast for 2021–2024 indicated an imminent deficit a major restructuring took place to guarantee a solid financial basis for the future.

6. Swiss Academy of Medical Sciences (SAMS)

Main achievements

The Central Ethics Committee of the SAMS leads a continuous in-depth reflection on the numerous challenges facing the healthcare sector. In 2015, the practical manual "Research with human subjects" (19) was published to give researchers and members of research ethics committees an overview of the complex regulatory framework within which research projects have to be conducted and evaluated since the Human Research Act (HRA) has come into effect.

In its career support activities, the SAMS focuses on areas that are crucial for the quality of academic medicine in the future but are not yet covered by established research funding structures. Together with the SNSF and with the support of private funders, the SAMS has led the national MD-PhD grants program since 1992, which allows up to 11 junior physicians each year to receive formal training in natural sciences, public health, biomedical ethics, or clinical research. In parallel, to attract early-career physicians to patient-oriented research, together with the G.&J. Bangerter-Rhyner Foundation, it has launched the "Young Talents in Clinical Research" program in 2017. The program supports up to 15 residents per year with protected time for research (beginner grants) and small project grants. 1 Mio CHF per year was made available from 2017 to 2020; a prolongation for a new funding period 2021–2024 is ensured by the Bangerter Foundation.

Finally, in collaboration with other stakeholders, the SAMS has actively participated in the reflection on possible improvements of the framework conditions for clinical research in Switzerland. This led to the publication of recommendations on the support of early career physician scientists, on a better scientific culture, and on the translation of academic discoveries to patients' benefits, to name a few.

7. Federal Institutes of Technology (ETH Domain) and Personalized Health and Related Technologies (PHRT)

Main achievements

Since today's clinical research and the development of personalized medicine require medical doctors to have a strong background in science, engineering, and information technology, the ETH board outlined the following goals in its strategic planning 2017–2024: 1) enable ETH scientists and clinicians to evaluate ETH technologies to identify and leverage potential benefits for patients; 2) enable knowledge exchange between scientists and clinical researchers; 3) equip the next generation of students with know-how of and access to clinical research data to develop next-generation biomedical insights. To reach these goals, the Personalized Health and Related Technologies (PHRT) initiative was launched in 2017.

The PHRT initiative funds interdisciplinary projects in education (doctoral and postdoc level), technology translation, and research to foster the development of precision medicine and health research. It also provides clinicians with access to ETH technologies. In close collaboration with the SPHN, the PHRT initiative connects hospitals and the ETH Domain institutions so that they can share, analyze, and use health data. The PHRT initiative further complements and operates in close cooperation with other programs in Switzerland, in particular, the ETH SFA Swiss Data Science Center (SDSC) and the SPHN. It is also linked to international research efforts, including The Cancer Genome Atlas (TCGA), the Cancer Moonshot initiative at the National Institutes of Health (NIH, USA), and the Global Alliance for Genomics and Health (GA4GH).

Since its launch, PHRT has funded 55 projects for a total of 50 Mio CHF. It has established three data analysis centres that generate genomic, transcriptomic, proteomic, and metabolomic data from clinical sample cohorts, providing a Swiss multiomic pipeline. The generated data are stored within the SPHN BioMedIT infrastructure and used by ETH Domain and SDSC scientists, clinicians, and collaborators.

Under the umbrella of University Medicine Zurich, which includes ETH Zurich, University of Zurich, and the university's four hospitals, researchers collaborate with clinicians on various projects, networks, and competence centers at the intersection of life sciences, engineering, and clinical application. In 2014, ETH Zurich and the University of Zurich further founded the Wyss Translation Center thanks to a private donation of 120 Mio USD. This initiative followed the 2013 establishment in Geneva of the Wyss Center for Bio and Neuroengineering which aims to accelerate neurotechnological developments for human benefit, including movement restoration, stroke rehabilitation, brain circuits, sensory, and advanced technology. It fosters collaboration between engineers, technologists, neuroscientists, and clinical scientists by bringing together the University of Geneva, the EPFL, and the University Hospitals of Geneva at the Campus Biotech.

In the field of education, ETH Zurich and EPFL are newly involved in the Swiss Medicine curriculum: in 2017 ETH Zurich launched a Bachelor's in Medicine, while EPFL students with a Bachelor in Life Sciences and Technology can pursue a Master's degree in Medicine thanks to a gateway program from the University of Lausanne set up in 2012. Moreover, ETH Zurich offers a number of courses that border medicine and technical sciences, such as the Master's in Health Sciences and Technology with a specialization in medical technology.

Appendix 4: Abbreviations

BBMRI-ERIC	European Biobanking and Biomolecular Research Infrastructure
CTU	Clinical Trial Unit
DCC	Data Coordination Center
DORA	San Fransisco Declaration of Research Assessment
Eawag	Swiss Federal Institute of Aquatic Science and Technology
EMPA	Swiss Federal Laboratories for Materials Science and Technology
EPFL	Federal Institute of Technology Lausanne
ETH	Federal Institute of Technology
FAIR	Findable, accessible, interoperable, reusable
FOPH	Federal Office of Public Health
HRA	Human Research Act
IICT	Investigator Initiated Clinical Trials
NRP	National Research Programme
PHRT	Personalized Health and Related Technologies
PREM	Patient-reported experience measures
PROM	Patient-reported outcome measures
PSI	Paul Scherrer Institute
SAKK	Swiss Group for Clinical Cancer Research
SAMS	Swiss Academy of Medical Sciences
SCTO	Swiss Clinical Trial Organization
SDSC	Swiss Data Science Center
SIWF	Schweizerisches Institut für ärztliche Weiter- und Fortbildung
SBP	Swiss Biobanking Platform
SERI	State Secretariat for Education, Research and Innovation
SNSF	Swiss National Science Foundation
SPHN	Swiss Personalized Health Network
SSPH+	Swiss School of Public Health Plus
SWTR	Swiss Science Council
UAS	University of Applied Sciences
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research