Project title: Leibniz ScienceCampus Digital Public Health Bremen (LSC DiPH)
Project number: W4/2018

Executive Summary

In its first funding phase, the Leibniz ScienceCampus Digital Public Health Bremen (LSC DiPH) aimed to develop the scientific foundations for digital public health (DiPH) by developing key concepts and tools through interdisciplinary research. This involved creating a comprehensive framework, addressing evidence gaps, integrating user perspectives, evaluating digital technologies, and fostering participatory approaches. Major milestones included publishing a comprehensive framework that integrates development and evaluation perspectives, addressing ethical, sociocultural, and policy considerations, and designing scalable participatory tools to address digital divides.

The comprehensive DiPH framework prioritizes public health needs over technology-driven solutions. Interdisciplinary definitions for DiPH interventions and health/medical apps were developed, along with a maturity index for classifying digital health capabilities, which is currently under consideration by WHO. The framework also supports policy development, including guidelines for implementation research frameworks and physical activity promotion programs for children. The campus advanced methods to integrate individual and community needs into DiPH development. We have developed a Digital Health Data Engagement Model, exploring user interaction phases with digital health tools. Research also revealed the long-term health impacts of digital and social media, such as lifestyle changes in children and the effects of design features ("dark patterns") on user behaviour. Strategies to counter health misinformation on social media were developed, alongside approaches to include underrepresented communities in health studies. We have also developed new evaluation paradigms for DiPH by mapping existing methods for digital tool evaluation, emphasizing interdisciplinary collaboration, and integrating economic evaluation models that integrate cost-effectiveness and sustainability. A transparency catalogue for carbon footprint analyses was created, and innovative methods for process evaluations of digital interventions were developed. Community and user engagement efforts led to the creation of participatory methods for urban health and environmental justice, including multilingual and culturally sensitive interventions for marginalized populations. Projects such as M-GENDER explored gender-sensitive adaptations, while participatory approaches were applied to bridge digital divides and increase digital health literacy.

The work was organized into four research clusters (RC): RC1 developed the DiPH framework. RC2 focused on demand-driven technology for health needs and countered harmful digital design features. RC3 addressed evaluation methodologies, including economic frameworks. RC4 worked on participation barriers, digital divides, and literacy.

Collaboration across institutes and acquiring funding for new multi-center projects, such as the DFG research group "Lifespan AI," strengthened the interdisciplinary approach. The COVID-19 pandemic accelerated the adoption of digital tools, with the LSC DiPH contributing to the national competence network and evaluating tools like the Corona Warning App.

Results so far include numerous publications, 11 PhD projects (eight completed), over €2 million in third-party funding for 18 projects, and scientific events such as symposia and an international summer school. Transfer activities involved a white paper on DiPH, a podcast series, and policy consultations, including advice on the Corona Warning App's development. Equal opportunities and career development were central to the campus' mission. Gender equality and work-life balance were promoted, and the Early Career Researcher Academy (ECRA) supported retreats, workshops, and conference participation. ECRA is central to the campus and expanded to include over 40 members, fostering interdisciplinary collaboration and self-organization.

Looking ahead, the LSC DiPH aims to further advance research on digital health literacy, evaluate AI-supported applications in public health, and secure structural funding to establish a competence center for digital public health in Bremen. These plans position the campus as a leading national and international hub for DiPH development, evaluation, and implementation.

1. Achievement of objectives and milestones

The core objectives of the first phase of the LSC DiPH were:

i. Developing a framework, joint concepts and terminology for digital public health;
ii. Understanding and integrating evidence, user needs, interests and perspectives on digital technologies for public health;
iii. Addressing the unclear effectiveness of digital technologies in public health (population health impact), including health economic aspects;
iv. Exploring and strengthening community and user engagement as well as participatory approaches.

i) Framework, joint concepts and terminology

We have published a first version of a comprehensive framework for the development and evaluation of DiPH technologies (https://osf.io/ub3w4;(1)). It goes beyond existing frameworks (2, 3) in integrating both the development and evaluation of digital technologies from a public health perspective. We have developed interdisciplinary definitions of DiPH interventions (4) and health/medical apps (5). Our glossary provides common DiPH terminology concepts (www.lsc-digital-public-health.de/forschung/glossary.html), and two PhD projects investigated legal and ethical frameworks for the sustainable utilization of mHealth technologies. Our work supports health policy: We have developed guidance to apply a renowned implementation research framework (CFIR) for public health apps (6), and one of the LSC PhD projects resulted in a DiPH maturity index (7), which will allow to classify countries and identify gaps and which is being considered by the WHO.

ii) Understanding and integrating evidence and user needs in DiPH development

We have developed and proposed the *Digital Health Data Engagement Model* in human-computer interaction and empirically explored several phases of this model (8).

Our research has highlighted that the digital environment affects health. We have demonstrated long-term health effects of digital and social media on the lifestyle of children, such as changes in nutrition patterns and preferences (9). LSC members examine how 'dark patterns', online design features that lead users to maladaptive online choices, affect health outcomes (10). We have also developed interventions to reduce the sharing of health-related misinformation in social media (11).

iii) Effectiveness of digital technologies for public health

We have examined and classified evaluation approaches to digital health tools (12), including N=1 trials for the self-evaluation of apps. We have developed guidelines for process evaluation of digital interventions by testing effective components and techniques (13). In terms of economic evaluation, we have developed decision-analytic cost-effectiveness models for digital public health (14) and defined the intersection of economic and sustainability evaluation (15). A transparency catalogue for carbon footprint analyses was published (16).

iv) Strengthening community and user engagement

We have developed novel transferable and scalable digital participatory methods that work in both high- and low- income settings and demonstrated the usability of such approaches in the context of urban health and environmental justice (17). Digitally supported participatory methods were applied (e.g. smartphone-based and photovoice) and options for knowledge transfer were explored (e.g., public exhibition of photovoice project results). We have developed intervention content to mitigate the digital divide in marginalized and vulnerable populations (18-21).

Overall result: In sum, our research in the LSC DiPH covers the broad spectrum implied in DiPH. We have provided new theoretical foundations for and empirical insights into key aspects of the evolving field of DiPH. All milestones outlined in the application were reached.

Financial statement

Almost € 1 million of the awarded WGL funds was spent on personnel. This included a postdoc and PhD students, the coordinator, two talent funds, student assistants, and research associates as part of the seed money projects. The remainder included budget for the ECRA, mainly spent on workshops and conference travel, open access publication costs, IT equipment and recruiting a panel of participants for digital health studies from the greater

Bremen area to the digital cohort study DigiHero (https://webszh.uk-halle.de/digihero/). Some aspects of the original financial plan were changed during the project. A major change was the substantial reduction of travel funds needed. The start of the project coincided with the beginning of the COVID-19 pandemic. This drastically reduced travelling to conferences and meetings. Delayed recruitment of staff and increased time requirement of some PhD projects created the need for a cost neutral extension of the project. Another aspect was the introduction of the instrument of talent funds.

2. Activities and obstacles

In the first phase, the LSC DiPH was structured in four thematic research clusters (RC), each supported and coordinated by a postdoc:

RC1 (*Framework Development for Digital Technology in Public Health*) developed the systematic framework for the use and assessment of digital technologies in public health (https://osf.io/ub3w4), logic models linking health outcomes and determinants and then specified whether and how digital technology can be integrated into the development of effective public health interventions.

RC2 (Demand-driven public health technology) focused on understanding how novel technologies can support individual and community health needs. Researches designed, developed and evaluated novel interfaces for individuals and communities to provide data for digital public health programs. We also investigated dark pattern in digital technologies that lead users astray (10).

RC3 (Evaluation) developed a systematic and cross-paradigmatic approach to identify and solve evaluation questions, collaboratively addressing a wide spectrum of interdisciplinary evaluation methods. One of the topics examined was the development of an economic framework to evaluate new digital public health interventions (22).

RC4 (Transfer and Participation) developed sustainable participation and transfer methods, in particular by focusing on methods to facilitate reach and usability and to address participation barriers. For example, this cluster identified and applied theories from multiple disciplines to describe, understand and modify digital divides and digital health literacy along multiple sociocultural fault lines (23).

Cross-campus interdisciplinary research was facilitated by: theme-open seed money proposals requiring cross-cluster collaboration, regular scheduled exchange through the steering committee and showcases, and the ECRA (see below). We have developed excellent collaborations not only between researchers of the Leibniz Institute for Prevention and Epidemiological Research – BIPS (BIPS) and the University of Bremen, but also among University of Bremen and Fraunhofer Institute for Digital Medicine MEVIS (MEVIS); research groups that previously had only limited contact. External funding resulted from collaborations that had not existed prior to the campus – e.g. the newly-funded DFG research group “Lifespan AI”. The LSC DiPH was frequently cited as a prime example of collaborative research by the University rector and attracted broad attention both nationally and internationally.

The **Early Career Researcher Academy (ECRA)** quickly became a central mechanism and infrastructure for campus integration by, for example, arranging a series of invited talks, workshops and exchange activities on joint issues. A particularly motivating feature, as reported by ECRA members, was the high level of self-governance including management of common resources. Consequently, the ECRA grew from its original core of 3-4 postdoc scientists and 6 PhD candidates to finally include more than 40 core and associated members.

The COVID-19 pandemic was a **major obstacle** at the beginning of the campus, hindering personal interaction. At the same time digital tools became as important as never before in daily life, presenting a kick-start for an LSC revolving around digitalization. Another important challenge in the establishment of collaboration structures in the LSC DiPH was integrating experts from multiple disciplines that rely on different epistemologies. Meeting the core objectives required highly interdisciplinary work, and our approach to facilitate such work was guided by methodologies for interdisciplinary research (e.g., 24). Frequent joint activities such as retreats helped to find common ground.

3. Results and successes

Publication: Our LSC DiPH has published a number of conceptual outputs on the evolving landscape of digital public health – examples include interdisciplinary definitions of health and medical apps (5), conceptual work on entry points of inequality in digital public health (25) and the publication of a "Digital Public Health" issue in the journal "*Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz*" (26) in 2020 which outlined key LSC DiPH topics such as participatory development (27) or unintended consequences (28). Moreover, we developed the international open access monograph "*Digital Public Health – An Interdisciplinary Perspectives*" with contributions from many LSC and external researchers, currently in press. The LSC DiPH became heavily involved in the nationwide competence network public health and COVID-19 and provided expertise on digital tools such as the Corona Warning App (CWA) as indicated above. COVID-19 was a first use case for the development of the Digital Public Health Framework (https://osf.io/ub3w4). Other highlights include a socioecological model on determinants of health inequity in digital environments (29), the development of a maturity index for digital health systems (30), various publications investigation the level of digitalization and digital health literacy in Germany (23), as well as important work on health misinformation and ways to combat it (31). In total, we have published about 80 peer-reviewed articles and about four book chapters, in addition to the monograph.
Theses/dissertations: LSC DiPH provided the background for eleven PhD projects, six funded by the campus. Eight PhD candidates have successfully completed their dissertation, three are very close to completion. So far, sixteen early career researchers have completed a bachelor's or master's thesis.
Third-party funding acquired: The LSC was extremely successful in acquiring additional funds in excess of €2 million with a total of 18 projects. Most competitive external funding resulted from collaborations that had not existed prior to the campus – for example, the DFG research group "Lifespan AI".
Scientific events: We organized scientific symposia to present our work and host internationally renowned scientists at the start and the end of the first phase of the LSC DiPH. The annual retreats provided excellent opportunities to discuss with invited speakers and to network among LSC DiPH scientists. In 2023 we organized a very well received first LSC DiPH Summer school on digital public health interventions, with about 45 international participants. The ECRA organized a variety of educational workshops to teach and promote important scientific skills and to advance their own interdisciplinary research.
Transfer: From the outset, the LSC acknowledged the fact that there is yet no clear understanding of digital public health. Members of the LSC therefore developed a White Paper Digital Public Health (32) in cooperation with the High-Profile Area "Health Sciences" of the University of Bremen. In May 2020, the LSC published a statement on Corona tracing apps (CTA). Subsequently, in November 2020, members of the LSC were invited by members of the German Parliament to a video conference to discuss future developments of the German CTA. LSC members were continuously involved in the evaluation of the CTA in close collaboration with the Robert Koch-Institute. The Stakeholder Advisory Board (StAB) of the LSC was a further component of LSC transfer, providing a discussion forum with experts from health insurances, policymakers, and information technology companies. Other transfer activities included newspaper articles, TV appearance, podcasts, social media and blogs.

4. Equal opportunities, career development and internationalisation

Gender equality and the balance of family, personal, work and career for all employees have been respected and advanced throughout the five years of the LSC. The Leibniz Equality Standards were observed and the Agreement for the Implementation of Equal Opportunities (AV-Glei) of the Joint Science Conference (GWK) was implemented. The University of Bremen, BIPS and MEVIS run certified programs promoting the balance of work and personal life. The support of young scientists played a major role in the LSC. A total of about 125,000 Euro was dedicated to ECRA, which young researchers used to independently organize retreats and workshops, finance research stays abroad, or co-financed their own conference

participation. ECRA was (and is) open to doctoral and postdoctoral students from both LSC DiPH and associated institutions.

5. Structures and collaboration

A consortium agreement between University of Bremen, BIPS, and MEVIS was signed. No changes in governance structures were necessary: As planned, representatives of all consortium members were represented in the steering committee of the LSC with bi-monthly meetings. The board of directors met monthly and supervised research and transfer activities. Through the StAB, invited talks at LSC DiPH events and online events, informal collaborations have been set up with the University of Oldenburg, University of Augsburg and the German Pension Insurance. The LSC DiPH established a cooperation and participation in the DigiHero study, a population-based cohort study for digital health research in German, established by the Martin-Luther-University Halle-Wittenberg (https://webszh.uk-halle.de/digihero/). The LSC DiPH financed the recruitment of a cohort of the greater Bremen area. This became a valuable research resource for the LSC DiPH scientists.

6. Quality assurance

The LSC Digital Public Health Bremen put in place various measures for quality control and assurance. The LSC DiPH follows the Leibniz Association's GSP principles and focuses on both structural and personal aspects of GSP. The LSC DiPH requires scientific manuscripts to be published open access, with limited exceptions. DEAL membership and campus measures (financial support to open access publication fees) support open access. The LSC DiPH is committed to the FAIR principles for research data: we strive to make all research data publicly available for re-use, in accordance with current privacy and data protection laws.

7. Additional resources

BIPS co-funded about € 1.2 million. More than €1 million were spent on personnel costs. This included a postdoc position, 3 PhD-students, statisticians, student assistants, research associates as part of seed money projects and support from our public relations and web design team, podcasts and other transfer projects. About k€ 200 of co-funding were spent on project related open access publications, travel costs, project meetings and retreats as well as IT- and camera equipment and other consumables. Uni Bremen co-funded about € 1.2 million. More than € 1.1 million were spent on personnel costs. This included two postdoc positions, 3 PhD-students, one talent fund, student assistants and research associates as part of seed money projects. Further, budget for the ECRA for workshops and conference travels, as well as IT equipment was included.

8. Outlook

The LSC DiPH was able to scientifically examine and support a time of explosive expansion of digital technology in public health and health services, as well as many other aspects of daily life during the COVID-19 pandemic. Prevention and health promotion will undoubtedly include more and more digital applications, and the development of AI technology adds another complex layer to the future of public health. We will increse our future research activities in the determinants of interacting with digital technology in public health by advance our research into digital health literacy of the population and of health professionals. This is linked to research on determinants of digital divides and measures to address them. We plan to evaluate the implementation of digital tools for core public health and prevention measures, advancing evaluation methods along the way, and researching potential adverse health effects of digitalization in specific groups, for example among adolescents. The campus will prepare an application for large-scale structural funding preferably in the form of a large-scale collaborative DFG project to sustainably establish a competence centre on digital public health in Bremen. The campus will thus continue to pursue its ambition as a science hub for digital public health development, evaluation and implementation nationally and internationally.

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