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Article

Co-producing active lifestyles as whole-system-approach: theory, intervention and knowledge-to-action implications

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Summary

Population health interventions tend to lack links to the emerging discourse on interactive knowledge production and exchange. This situation may limit both a better understanding of mechanisms that impact health lifestyles and the development of strategies for population level change. This paper introduces an integrated approach based on structure-agency theory in the context of 'social practice'. It investigates the mechanisms of co-production of active lifestyles by population groups, professionals, policymakers and researchers. It combines a whole system approach with an interactive knowledge-to-action strategy for developing and implementing active lifestyle interventions. A system model is outlined to describe and explain how social practices of selected groups co-produce active lifestyles. Four intervention models for promoting the co-production of active lifestyles through an interactive-knowledge-to-action approach are discussed. Examples from case studies of the German research network Capital4Health are used to illustrate, how intervention models might be operationalized in a real-world intervention. Five subprojects develop, implement and evaluate interventions across the life-course. Although subprojects differ with regard to settings and population groups involved, they all focus on the four key components of the system model. The paper contributes new strategies to address the intervention research challenge of sustainable change of inactive lifestyles. The interactive approach presented allows consideration of the specificities of settings and scientific contexts for manifold purposes. Further research remains needed on what a co-produced knowledge-to-action agenda would look like and what impact it might have for whole system change.

Key words: structure and agency, population health intervention research, knowledge exchange, co-production, active lifestyle

INTRODUCTION

There is clear evidence of the connection between physical activity and the health of populations, including the obesity epidemic and increasing rates of non-communicable diseases such as Type 2 diabetes (Physical Activity Guidelines Advisory Commitee, 2008, United Nations, 2011). Physical activity has been linked to the concept of lifestyle. 'Active lifestyle' tends to have very diverse meanings in public health. Often the term is used interchangeably with 'active living' and 'physically active lifestyle' (Haskell *et al.*, 2012). For some it emphasizes the health choices one makes regarding individual health behavior in the form of physical activity levels. Such an understanding is linked to the inherent tendency in public health towards lifestyle drift whereby the policy drift is towards structural rather than individual actions. Although addressing individual behavior is a relevant part of health promotion, it can distract attention from the broader drivers of such behaviors such as the underlying structural determinants (Popay *et al.*, 2010). This paper introduces an integrated approach that is based on structure-agency theory and places active lifestyles in the context of 'social practice'. We understand social practice as everyday actions and interactions in specific settings that shape an individual's agency and choice (Cohn, 2014, Frohlich and Abel, 2014, Veenstra and Burnett, 2014).

As part of social practice, physical activity patterns of active lifestyles must not be perceived as distinct 'behaviors' but as embedded into social action. Therefore, we use a concept of 'co-production' that emerged in the broader context of social science and public policy theory (Ostrom, 1996, Bovaird, 2007). It has also been applied to the management of health systems and services (Dunston *et al.*, 2009, Batalden *et al.*, 2015). In the context of our work, the concept of co-production of active lifestyles focuses especially on the interplay of social practices of four groups of social actors: population groups, professionals, policymakers and researchers. We will introduce a system model to show how active lifestyles of population groups are co-produced by the other three groups of actors. Conversely, we will indicate how related professional, policy and research practices are co-produced by population groups and the other actors.

Beyond understanding the co-production of active lifestyles, public health has a vested interest in sustainable change of inactive lifestyles. Early attempts have been made to systematically consider implications of the concept of active lifestyle for designing and implementing interventions (Rütten, 1995). However, the full potential of population intervention research (Hawe and Potvin, 2009; Potvin *et al.*, 2014), complex interventions (MRC, 2008) and a whole system approach (Hawe, 2015a,b) has rarely been used in this context. Several overarching messages can be derived from this growing body of research:

Embrace complexity

Attempts toward lifestyle change at the population level needs to embrace the complexity of interacting components involved in the whole system that produces and is reproduced by those practices. Interventions typically must be comprehensive and address both people's agency, i.e. their capacity to make choices and the structural context that enables and constrains their capacity to act (Hawe, 2015a,b).

Use theory

Appropriate use of theory is needed for a fuller understanding of complex systems. It can help to define key components and structural issues, to model their relationships and interactions among different variables, offer supplementary insights, or strengthen results (de Leeuw *et al.*, 2016). Theory is also essential for designing feasible strategies for intervening in a whole system. It can be applied to define potential entry points into the system and for steering the direction of the whole systems change (de Leeuw *et al.*, 2015).

Adapt to context

Adaptation is a fundamental pre-requisite for adequate intervention implementation that aims at structural change. The need for adaptation refers to all aspects of the intervention cycle (Trickett, 2009; Hawe, 2015b). For example, the participation of different stakeholders in intervention planning can help to increase its fit with real world conditions (Bisset and Potvin, 2007; Bisset *et al.*, 2009), but may lead to changes in the original program. Moreover, adaptation is a crucial condition for 'normalization', i.e. the integration into routine service (May, 2006) and sustainability (Chambers *et al.*, 2013; Schell *et al.*, 2013). It is also important if a successful intervention is to be transferred to a different context.

Integrate knowledge

Intervention studies need to reflect upon and systematically consider the 'recursiveness' of research or feedback

loops within the intervention process. Intervention research has to be self-reflexive with respect to the 'agency' of science. Although researchers traditionally might prefer the role of observer or referee, they are always part of the same enterprise, even if they wish it were otherwise. Ideally, this process works as mutual learning in the sense of transdisciplinarity, i.e. the involvement of relevant partners, academic and non-academic, in the co-design, co-production and co-dissemination of research, in a joint effort to address common and complex problems. Interventions conducted, outcomes achieved and experience obtained can and should be integrated into the subsequent steps within future research (de Leeuw *et al.*, 2008; Lewis and Russell, 2011; Jansen *et al.*, 2012; Bergmann *et al.*, 2013; Marshall *et al.*, 2014, 2016).

Building on these messages, this article will first introduce a system model that describes and explains co-production of active lifestyle related to the social practices of selected populations groups, professionals, policymakers and researchers. Second, potential intervention models are presented to address the co-production of active lifestyles and to discuss different mechanisms of transformation and adaptation. For that, we will present examples from Capital4Health, a German research network that focuses on active lifestyles and an interactive-knowledge-to-action approach. Case studies from the network will be used to illustrate how different implementation contexts might be linked to different approaches to co-produce active lifestyles among specific population groups in diverse settings. We end the paper by highlighting the benefits of the interactive-knowledge-to-action strategy, links to other knowledge exchange approaches, and directions for future research on how to co-produce active lifestyles using a transdisciplinary whole system approach.

A SYSTEM MODEL ON THE CO-PRODUCTION OF ACTIVE LIFESTYLES

A system model on the co-production of active lifestyles is shown in Figure 1. The model takes a social practice perspective through focusing on four key social actors, i.e. population groups, professionals, policymakers and researchers. It explains the relational actions between those actors that shape or impede interactive social practices for the co-production of active lifestyles. We also foresee additional groups' social practices to be relevant for the respective social practices from a whole system perspective (indicated by the empty circles in Figure 1).

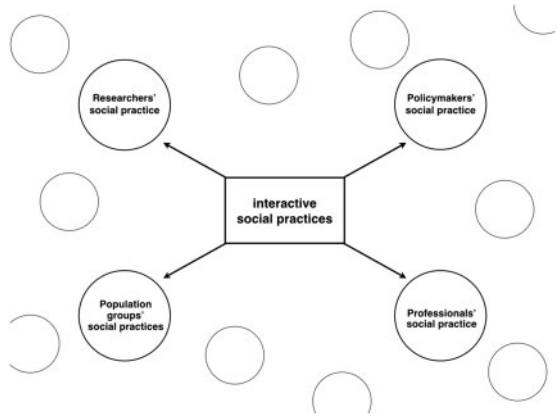

Fig. 1: System model on the co-production of active lifestyles.

For example, additional social practices might pertain to the media, parents in school and child care center settings or unions in the workplace setting. However, even in whole system models there is a trade-off between complexity and parsimony. In order to keep the model intelligible and manageable, we do not specify additional practices. At the same time, we assume that interactions among the four key social practices constitute the significant structural elements involved in the co-production of active lifestyles. These interactions provide key entry points for potential change, adaptation and transformation of contexts.

Key social practices of the four relevant groups

Populations groups' social practices

Adopting a public health perspective, we define active lifestyles as part of social practices of population groups that are embedded in their daily routines (for lifestyle see Giddens, 1984; Rütten, 1995; Frohlich *et al.*, 2001; Abel and Frohlich, 2012; Cohn, 2014), for 'social practices' see Cohn, 2014, Veenstra and Burnett, 2014). For example, children may participate in certain sports as part of school routines [e.g. in physical education (PE) and during recess] or as part of their leisure time routines (e.g. together with their parents or in a sport club). Different co-actors are regularly involved in such social practices; e.g. in PE, teachers and classmates play a crucial role in co-producing active lifestyles as they may increase or decrease the quantity and quality of activities of the children in PE lessons. Furthermore, other actors might indirectly influence the production of active lifestyles in a given population. Policymakers could have an impact on the school curriculum for PE and investments in infrastructures that could support physical activity

during recess (Wang *et al.*, 2003, 2008). Also, researchers may have an indirect impact if, for instance, new educational tools that they have developed and tested in scientific studies are applied by teachers in PE classes (Dudley *et al.*, 2011; Quitério, 2012; Lonsdale *et al.*, 2013; Barrett *et al.*, 2015).

Professional practices

As indicated in the school example, active lifestyles of population groups are influenced by social practices of professionals who are their co-actors in different settings. Referring to the community setting, for instance, organizational routines of public agencies that aim at promoting active lifestyles (e.g. through marketing activities) may affect certain population groups. At the same time, those routines might systematically neglect others (e.g. socially disadvantaged groups) (Lorenc *et al.*, 2013; Frahsa *et al.*, 2014). Moreover, professionals from the private sector and volunteers from non-governmental organizations (NGOs) are also relevant 'multipliers' in the co-production of active lifestyles at this level. For example, sports clubs often represent themselves as offering 'sport for all' and acting as a 'bridge to equality, integration and social inclusion'. However, this representation tends to be counteracted in some cases where social practices of volunteers in clubs may especially encourage active participation of young male population groups with a non-migrant background.

Policymaking

The practices of policymaking, both in institutionalized settings of 'collective choice' (such as governmental bodies) as well as in more informal policy arenas (Ostrom, 2005) (such as citizens' advisory boards) have a particular impact on the co-production of active lifestyles. For example, decisions about rules and resources affect both the production of active lifestyles by different population groups and professional practices related to them. The influence of such public policy decisions on the co-production in specific settings (e.g. related to regulations for PE and funding for playgrounds in schools) have already been indicated above. Also the importance of policymaking in whole community development and urban planning, e.g. for promoting active transportation lifestyles, might be highlighted here. Policymaking in private companies or NGOs is of relevance for the co-production of active lifestyles as well. For example, a company board may foster or hamper employees' active lifestyles. Such a board decides about resources for health promotion or rules on vocational training (e.g. whether the curriculum is to include physical activity-related components or not). Thus, the term policymakers should also consider those decisionmakers. People in those positions shape organisational policies and differ from professionals whose main roles relate to implementation of decisions and day-to-day interactions with respective endusers or population groups in their settings.

Research

Research and publications on health-related physical activity have been rapidly expanding during the last four decades. A substantial body of scientific evidence is available to guide interventions aimed at promoting active lifestyles (Rütten *et al.*, 2016). The content, e.g. the scientific knowledge related to effective interventions, has been frequently discussed. However, issues relating to the implementation and dissemination of research into public health practice have only recently become more prominent in scientific discourses (Green *et al.*, 2009; Glasgow *et al.*, 2012; Tabak *et al.*, 2012). In particular, it is still under-researched how social practices of scientific knowledge production may affect social practices outside the institutionalized settings of the scientific community. For example, a randomized control trial (RCT) may provide a substantial contribution to the existing body of knowledge on the efficacy of a physical activity intervention to prevent dementia in older adults. However, the external validity of such an intervention may be very low and it might not be easy or even possible to adopt in real world situations (Green and Glasgow, 2006). The social practices of research usually applied in RCTs systematically attempt to avoid any interference with the 'objects' of the investigations or with the context in which the intervention takes place. In addition, RCTs tend to apply often narrow eligibility criteria for participant recruitment. Thus, despite its high recognition in academia, this kind of research may not be able to readily influence professional practices and substantially contribute to the active lifestyles of the populations that are the purported targets of such investigations. In contrast, there is an emerging field of research approaches that consider the social interaction with different stakeholders and population groups and the co-production of knowledge as essential components of their research practices. Such approaches perceive a mutual adaptation of both the intervention and the context (capacity building) as a prerequisite for sustainable implementation into organizational routines and the substantial promotion of active lifestyles of population groups (Bisset and Potvin, 2007; Bisset *et al.*, 2009).

Key interactions and intersections between social practices

In our outline of the system model, we have indicated several interactions. In particular, we highlighted the way in which the quantity and quality of physical activity in the social practices of different population groups are 'co-produced' by social practices of professionals, policymakers and researchers. In this section, we want to add two characteristics of interactions among these four practices: (i) the mutuality of the relationships and (ii) the intersection of structures where the interaction occurs. These aspects highlight essential pre-requisites for both the reproduction of structures across different contexts and the potential for a whole system change.

To explain the reciprocity of the relation between different components, our model refers to the 'duality of structure and agency' as outlined in Giddens' seminal structuration theory (Giddens, 1984). For Giddens (Giddens, 1984, p. 25), structures are 'both the medium and the outcome' of the practices that constitute social systems, the reproduction of structures as well as structural change depending on the human agency involved in these practices. Conversely, structures, operationalized by Giddens (1984) as rules and resources, both restrain and enable social practices. For example, the reproduction of deductive approaches to knowledge transfer is still dominant in the scientific community. Herein, scientific evidence is used to directly derive practical solutions for public health problems. This reproduction of deduction reflects the rules (e.g. focusing on the internal validity of studies) and resources (e.g. scientific rewards in terms of prestige and position) of the social practices within the scientific system. This traditional approach also reflects many confirmative (re-)actions from other stakeholders, e.g. policymakers, professionals and population groups that are focused on consuming knowledge rather than co-producing it. Another example of the reproduction of structures endorsed by the cross-component interactions includes the following: PE teachers who mainly focus on competitive sport practices in their PE classes may mirror the rules and resources of the school system (e.g. curriculum, grading rubrics). In addition, those rules and resources may be co-produced by the population groups involved (sporty students take active roles, sedentary students avoid them). Moreover, parents, policymakers (e.g. from the sport sector) and even researchers (e.g. from specific sub-disciplines of sport science like coaching science) might contribute to the reproduction of such structures.

Although Giddens' own work mainly focused on the reproduction of structures, other authors have highlighted the potential for structural change related to the duality of structure and agency as well as to system dynamics (Magnusson and Stattin, 2006; Thelen and Smith, 2006). Among those, Sewell (1992), in particular, introduced different axioms to explain how the interaction of structure and agency can lead to structural change. One of them, i.e. the 'intersection of structures', indicates that the structures related to different social practices do not simply exist side by side but often overlap. This is particularly relevant for the cross-component interaction in our system model. For example, the head and/or the staff of a day care center may change physical activity-related practices if they find new resources (e.g. education, political support, funding) through collaboration with relevant researchers and policymakers. They might even be encouraged to change the rules that structure their daily routines (e.g. add new focus on outdoor physical activities). Conversely, the good practice example of a physical activity-friendly day care may become a new resource for the social practices of the policymakers and researchers involved. The collaboration of different stakeholders, as just indicated, may increase the external validity of a scientific study related to the day care center context which in turn may have an impact on the potential for third party funding or publications in the future.

From a public health perspective, it is particularly relevant to underline the potential of intersection of structures. Those intersections are created through the interaction of the key components of our system model. Intersections include a considerable potential for the empowerment of population groups involved (Jagosh *et al.*, 2015). For example, in a project focusing on promoting active lifestyles (the BIG project), women in difficult life situations were enabled to act beyond changing their own social practices towards more active lifestyles. They also became co-producers of new policy rules and scientific studies in collaboration with professionals, policymakers and researchers (Rütten *et al.*, 2009; Frahsa *et al.*, 2011). It is important to note, however, that this kind of whole system change may require a systematic approach to facilitate and steer the process. In the BIG project, both a multilevel conceptual model (BIG8, cf. Rütten and Gelius, 2011) and an academia-driven process model (co-operative planning, cf. Rütten, 1997; Frahsa *et al.*, 2014) were used for these purposes.

INTERVENTION MODELS ON THE CO-PRODUCTION OF ACTIVE LIFESTYLES

The system model outlined earlier not only improves our understanding of the mechanisms of the co-

Table 1: Capital4Health sub-projects: comparison of settings, groups addressed, co-production intervention, intervention outputs and structural outcomes foreseen

Subproject	QueB	Health.edu	PArC-AVE	ACTION for men	PATEN
Abbreviation is short for	To develop quality for physical activity	Health-related PE	Physical activity related competence in work site settings	Physical activity for men in rural areas	Physical activity for the elderly network
Settings	day care centers ($n = 14$)	secondary schools ($n = 4$), credential program schools ($n = 8$) universities ($n = 2$)	worksite, vocational training ($n = 3$)	Municipalities ($n = 2$)	senior residences ($n = 3$)
Groups addressed	staff ($n = 50$) children ($n = 500$)	pupils ($n = 300$) teachers ($n = 8/16$) lecturers ($n = 8$)	trainees ($n = 400$) trainers ($n = 22$)	men > 50 years ($n = 500$) local stakeholders ($n = 20$)	residents ($n = 300$) staff/general practioners ($n = 40/80$)
Processes for interactive health practice	participatory organization development	cooperative planning	cooperative planning	capacity building process	cooperative planning
Interventions to be implemented	quality certification	Implementation of curriculum into PE classes and teachers' training	Implementation of interprofessional education	Interventions to promote awareness and acceptance towards PA	Adaptation of guidelines and mission statements
Structural outcomes addressed	participatory interventions to promote health competence	Classes to promote health competence	PA offers to promote PArC	Etablishment of sustainable interventions	Coaching to promote health competence
Functionings addressed	increase in PA levels among children PA levels among staff	increase in sport-related health competence among pupils competence-oriented teaching among teachers and lecturers	increase in physical activity-related health competence among trainees	Increased awareness and acceptance towards PA among inactive men	increase in PA levels and improved QoL among residents

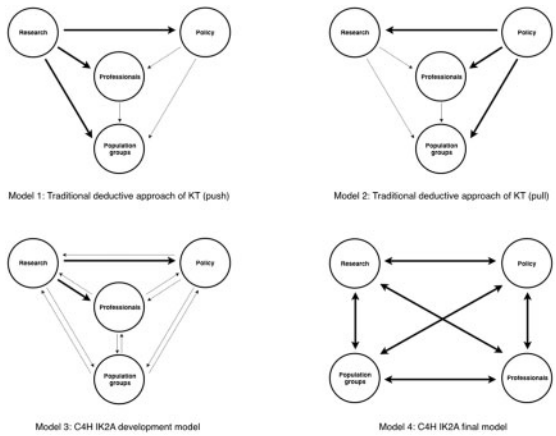

Fig. 2: Intervention models to implement the (co-)production of active lifestyles.

production of lifestyles. It also indicates both barriers to overcome interactive social practices that reproduce inactive lifestyles and opportunities for change (i.e. intersections of structures). In the remainder of this article, we systematically apply this model to the development and implementation of population intervention studies.

Four different intervention models are presented. As we want to indicate how these models work in practice, a set of case studies from a German research network is first introduced. They aim to illustrate how to address the co-production of active lifestyles and to reflect different mechanisms of transformation and adaptation.

The consortium 'Capital4Health—Capabilities for an active lifestyle: An interactive knowledge-to-action research network for health promotion' (funded by the German Federal Ministry of Research, 2015–2018/FKZ 01EL1421A, http://www.capital4health.de/en) is envisaged as a transdisciplinary consortium based in and around the German state of Bavaria, and is comprised of research institutions, as well as policy and professional partners. Empirical subprojects are used to develop, implement and evaluate interventions. Those interventions work across the life course to promote active lifestyles. Active lifestyles are conceptualized as part of the social practices of different population groups. In line with our system model, the interventions therefore also aim to adapt social practices among relevant professionals and among policymakers. Accordingly, those interventions are designed to develop capacities at the organizational and system levels in relevant settings (e.g. schools, workplace, senior housing, community). The goal is to sustainably implement social practices that convert such active lifestyle actions into routine services.

All subprojects are utilizing participatory planning/implementation approaches and share a common transdisciplinary perspective. However, they differ in their respective disciplinary backgrounds. Thus, they each differ with regard to the concrete planning and implementation tools they apply to achieve the specific intervention outputs and structural outcomes being addressed (see Table 1).

We describe below case studies from three out of the five subprojects.

i. The subproject *QueB* focuses on day care centers. It is aimed primarily at changing social practices among staff and children via a participatory organizational development process that includes a quality certification.
ii. The subproject *Health.edu* works in the school and university settings and aims to develop sport-related health competence via the orientation of PE classes toward health promotion and the adaptation of PE teacher training in the university setting. *Health.edu* uses a cooperative planning approach involving teachers, decisionmakers, as well as students in jointly developing the intervention.
iii. The subproject *PArC-AVE* applies a cooperative planning process to apprenticeship and vocational education. Trainees', trainers and company decisionmakers jointly develop physical activity offerings in the workplace as well as activities to integrate the issue of active lifestyle promotion into the inter-professional education curriculum for the trainees.

Based on the system model outlined earlier, Figure 2 shows four different intervention models to promote co-production of active lifestyles. As indicated by the case examples from the Capital4Health research network, the intervention models may overlap in actual intervention practice. Moreover, the models are dynamic so that, while one model may be dominant when an intervention starts, the project may gradually evolve and shift towards other models over time.

The traditional 'push-and pull-approaches' (Models 1 and 2)

Models 1 and 2 represent traditional deductive models of knowledge transfer that reflect the typical experience of researchers as well as stakeholders from policy and professional background during their project-related interactions and activities. They include the array of expectations concerning the kind and direction of

interactions among four perspectives once a new interaction or project starts.

Models 1 and 2 differ in two aspects. Model 1 represents a traditional 'push-approach' of knowledge transfer (Lavis *et al.*, 2003). Researchers may either directly approach population groups, policymakers and professionals. Alternatively, they may only approach one specific group, such as policymakers or professionals, in order to influence the course of interactions with population groups toward a specific direction (e.g. 'evidenced-based policy and practice').

Model 2 indicates a 'pull-approach' to knowledge transfer (Lavis *et al.*, 2003) in which researchers are approached by others, e.g. policymakers, to produce knowledge that can either support policymaking directly (e.g. request for scientific evidence that can be used for policy development) or can help improve professional practices and health practices of population groups.

Although there is a vast body of literature demonstrating that these deductive approaches of knowledge transfer do not work as effectively as one might imagine (Green and Glasgow, 2006; Brownson *et al.*, 2012a), they are still quite dominant. The persistence indicates a particular structural challenge that needs to be addressed by a more systematic approach to structural change.

For example, initiators of the Capital4Health research network envisioned an interactive knowledge-to-action approach right from the start based on principles of co-production. Nevertheless, they had to deal with the established structures of the research and funding contexts that were very much in line with Models 1 and 2. For example, funding opportunities and the call from the German Ministry of Education and Research that funded the research network focused on scientific knowledge production and transfer in the area of prevention, with a particular focus on active lifestyles (pull-approach). Research institutions were not the only ones eligible to apply. However, the way in which the call was framed and reviewed attracted academia-driven proposals almost exclusively (push-approach). Moreover, within the subprojects, these push orientations partially persisted. One main challenge occurred around the relevance or consequence of the current state of active lifestyle research. Researchers in health.edu pointed out that the current state of teaching PE would not address the most recent evidence in sports pedagogy research on sport-related health competence. They wanted to push professionals (i.e. teachers) to improve their practices. To a certain degree, policymakers from the responsible ministry supported that perception. They argued that teachers and lecturers should implement the most recent curriculum which is based on current scientific evidence.

At the same time, researchers, during their early interactions with the other perspectives, experienced the limitations of a push-approach. For example, one policymaker in health.edu repeatedly stressed that sport-related health competence would only constitute one of several equally or even more relevant competences within the PE curriculum.

In the subproject PArC-AVE, which targeted apprenticeship and vocational education, a similar challenge occurred. Although the researchers were very interested in exploring and promoting physical activity-related health competence based on the most recent evidence base, policymakers from the company-based settings pushed back. For example, a policymaker from a car-producing company and one from a hospital stated that such a competence was of minor interest to their companies and would not be on their agenda to promote. It turned out to be very challenging to engage these policymakers in a co-production process for change.

Another important limitation stemming from the dominant pull- and push contexts is related to the very weak involvement of professionals and population groups' perspectives in designing the sub-projects. That is also due to funding conditions that ask for participatory research approaches but do not allow to support societal partners financially. Thus, the chance to involve them as intensive as necessary in the common learning process and—most important—in the problem constitution and formulation of research questions is very low. For example, in health.edu teachers and pupils who could inform researchers and policymakers about assets for and barriers to implementing the new curriculum and sport-related health competence in P.E. practice had no significant input to, or impact on, the initial design.

The transition to the change-oriented approach (Model 3)

Model 3 aims to overcome the limitations of these deductive models by establishing a more interactive knowledge-to-action intervention embraces the complexity of such interventions along with the co-production of knowledge (Holmes *et al.*, 2016).

On the one hand, Model 3 is 'pragmatic' enough to be compatible with the dominant push and/or pull practices, which are also typically supported by the practices of involved research and funding agencies. On the other hand, Model 3 is 'change-oriented'. This approach marks a starting point and a means for developing mutual trust and a collaborative relationship among

researchers, policymakers and professionals in the course of the project planning process.

Given the dominance of Models 1 and 2 with respect to the research and funding contexts at the outset, Capital4Health has introduced systematic approaches to support the subprojects' development towards Model 3. First, the coordinating group for Capital4Health accepted only proposals for subprojects that contained a collaborative planning and implementation method. Second, as part of central project management reflective interviews take place twice a year with researcher teams from the subprojects to discuss the current state of co-production and the necessary steps to promote productive interactions. Third, a transdisciplinary steering committee has been established. It consists of researchers as well as selected policymakers and professionals from all subprojects. The committee's role is to supervise action and foster useful exchanges between subprojects. At meetings, generic challenges in co-production are presented and potential solutions are discussed. Working in this way, the committee supports challenges to be made explicit and it provides opportunities for learning across subprojects.

The cases of QueB and PArC-AVE will serve to illustrate how a transition from Models 1 to 3 might be approached. Using collaborative planning and implementation methods, both subprojects focused mainly on strengthening the professional perspective in the first phase of Capital4health. The subprojects differed, however, with regards to the approaches chosen. QueB focused on the interaction between researchers and daycare staff. The project has assessed the participating daycare centers and has been using the results for a participatory organization development process. Researchers trained as systemic coaches have been supporting staff in setting goals regarding physical activity promotion in the respective daycare centers. They have been collaborating in developing concrete actions on how to increase physical activity in day-to-day work and in how to evaluate achievements. Throughout this process, both researchers and staff have gained insights into existing barriers for active play. Examples include concerns about legal responsibilities for injuries from potential accidents and implicit rules that stop children from free active play. Jointly, staff and researchers have been working on overcoming those barriers. They organized a training session on legal issues with relevant organizations and re-assessed implicit barriers and rules to agree new and explicit rules that foster free active play at their daycare centers.

One major challenge that QueB was facing in the planning process is the poor engagement of policymakers, heads of centers and responsible agencies. Children visiting the day care centers were also not actively involved in the assessment, other than participating as subjects in the physical activity assessments that occurred. Parents received information only sporadically.

The subproject PArC-AVE has implemented a multilevel cooperative planning approach that involves trainers, trainees and ideally policymakers, who serve as decisionmakers for training at the participating companies. Within PArC-AVE, it turned out to be really challenging to initiate interactions between the different perspectives at the car producing company. Within the company, people were used to services and products provided by specialized and very hierarchically operated divisions. Policymakers, trainers and trainees typically are not used in negotiating and developing comprehensive catalogues of actions that might impact their own work and those of others. At the car producing company, thus, two planning groups were established. One cooperative planning group was set up to develop goals and concrete actions to promote physical activity among trainees. Here, a tutor system was developed to sensitize new trainees to an active lifestyle. The other group has been establishing an inter-professional curriculum that could guide trainers in developing physical activity-related competence. Here, existing guidelines are being adapted to promote active lifestyles at work as well and the issue of PA-related health competence will be integrated into regular workshops with trainers.

Reflective interviews conducted by the research coordinators highlighted the challenge of actively involving not only professionals but also relevant policymakers in the collaborative planning process. Researcher teams identified how overcoming of this challenge was essential to progress and sustainable implementation in all subprojects. Subsequently, the Transdisciplinary Steering Committee conducted a meeting on how to increase policymakers engagement in Capital4Health. Researchers and professionals from PArC-AVE presented their case. An expert on the development of transdisciplinary approaches presented consultancy and methods to support the engagement of policymakers. This allowed to discuss specific solutions for PArC-AVE, e.g. using terminology familiar to company staff and routines usual for company project presentations. The case consultancy increased researchers' understanding of the very different organizational logics outside of academia. It also helped to increase the engagement of policymakers who had been already involved in the subprojects and the Steering Committee. Their awareness grew about the potential benefits of the different projects. They specified both general terms of collaboration

terms and divisions of labor and roles within the projects. However, thus far a main challenge has persisted. Although the existing participating policymakers got more engaged, no additional policymakers joined the Steering Committee or the respective subprojects.

The 'ideal' interactive approach

Finally, Model 4 in Figure 2 shows an 'ideal' interactive knowledge-to-action setup. It builds on the processes indicated in Model 3, carrying forward the initial two-way collaborations of this model. At the same time, it transcends the previous model as it is characterized by a mutual relationship between all sub-groups and their practices.

All sub-projects of the Capital4Health research network aim to have at least Model 3 in place at the end of the first funding period (after three years). For QueB, this would mean to further integrating policymakers' perspectives as wel as making a greater effort to involve parents' and children into the process, thereby transforming it into a holistic and sustainable organizational development process. Another goal for QueB is to establish a peer-coaching approach during which staff from one center coaches staff from other day care centers rather than relying on the researchers' expertise only. The insights from peer-coaching would also enable more interaction between researchers and professionals rather than the relatively one-sided coaching that they started with. The involvement of policymakers and a peer approach appear to be particularly crucial from a sustainability point of view—there are high levels of change-over among staff in day care centers due to parental leaves.

For PArC-AVE, a similar goal would be to further integrate policymakers in the planning process to allow for comprehensive organizational change rather than the very focused (and limited) scope that currently has occurred within those large company entities.

Additionally, the future set-up of Capital4health with regard to the second funding period of the research network (2018–2021) will concentrate on the transition from Models 3 to 4. For this upcoming Phase 2 of Capital4Health, only those subproject-proposals that have been conceptualized collaboratively by researchers, policymakers and professionals have been accepted. This decision aims to turn real-world problems into research questions rather than bringing research questions to the real world. In addition to this innovation, Capital4Health will foster development towards Model 4 by focusing on the integration of population groups. Herein, the challenges, mentioned above, are considered. For QueB, the focus will be on ensuring children's (and parents') active involvement in the planning and implementation of physical activity promotion in their day care centers. For Health.edu, the focus will be on the integration of students into curriculum development and implementation. For PArC-AVE, one goal is trainees' empowerment regarding physical activity-related health competence by working towards strengthening their position within the cooperative planning processes.

A second focus is on scaling-up the subprojects, which will require a more active role of policymakers in particular. For QueB, scaling-up refers to sustaining the implementation via peer-to-peer-trainings and official commitments from additional providers to the project. For Health.edu, it is about implementing the project in additional schools and universities. For PArC-AVE, the goal is to broaden the reach to additional companies and training programs.

DISCUSSION AND CONCLUSIONS

This article outlined a theory-based system model integrating key criteria of how to promote the co-production of active lifestyles as a whole system approach. It presented four intervention models describing how co-production of active lifestyles could evolve and the case of the Capital4Health research network in applying these models in research practice. The interactive knowledge-to-action approach presented here allows consideration of the specificities of settings and scientific contexts. At the same time, it introduces a set of generic key groups and their practices, as well as a set of general assumptions concerning the interdependencies of different social practices and interactions. In doing so, the paper has contributed to the need for new strategies to address the intervention research problem of sustainable change of inactive lifestyles through a whole system change approach (Hunter, 2013; Hawe, 2015b).

The use of the models in the Capital4Health research network hints at their potential for diverse purposes: heuristic, analytical and integrated. For example, one could identify and analyze different entry points and pathways to increase interactions and establish an interactive knowledge-to-action mechanism for promoting an active lifestyle. Comparative analyses could produce a series of case studies to show the context-based specific (e.g. research discipline-related differences) as well as generalizable features that span across and beyond different contexts and allow for theory enhancement in whole system change. So far, lessons learned indicate the inertia of existing research and funding structures. Although the initiators of the network were advocating for transdisciplinary approaches right from the start and

were supported by individual researchers, reviewers and funders, the research and funding context, in contrast, supported the development of deductive approaches to knowledge transfer commensurate with intervention Models 1 and 2 when the network was set into practice. Second, at least some of the applied strategies (e.g. cooperative planning), used by the Capital4Health consortium in the first funding phase (2015–2018), were partially successful in supporting a shift in subprojects towards a more interactive knowledge-to-action approach. In particular, an integration of perspectives from researchers and professionals has been reached in most subprojects. However, policymakers are still quite hesitant to take a more active role and populations groups so far were rather treated as research subjects than as participants in the subproject development.

Nevertheless, the theoretical framework using the system model and the different intervention models presented above turned out to be a helpful frame of reference to reflect ongoing processes in the network and to steer its further direction. For example, the theoretically informed and intended transformation towards Model 4 has led to the definition of the two major foci in the proposal guiding the second funding phase: i.e. active population group involvement and scaling-up as a particularly interesting issue for more active policymakers' engagement. In this respect, Model 4 can be regarded as a conceptual model that supports and assesses the quality of participatory and impactful research. By describing their experiences, challenges, success and failure, subprojects successfully making use of this focus on transdisciplinary quality aspects, can provide future interactive knowledge-to-action researchers with some guidance how to structure their participatory research processes.

The interactive knowledge-to-action approach introduced in this article is driven by a recognition of the dynamics at the interface of research, policy and practice. In contrast, other models of co-production at the nexus between research, policy and practice, may they be termed as dissemination and implementation research, engaged scholarship or integrated knowledge translation, all of which tend to focus in a minor way on methods for developing co-production for a whole system change (e.g. Graham and Tetroe, 2007, Van de Ven, 2007; de Leeuw *et al.*, 2008; Brownson *et al.*, 2012b; Tabak *et al.*, 2012).

This findings can provide a starting point and guidance for further research on effective interactive social practices, the influence and weight of the different practices involved and on measures of impact on the co-production of active lifestyles among specific population subgroups. Further research would also be essential on how to best develop a co-produced research agenda and what difference such co-production would make in the promotion of active lifestyles, and on the impacts it might have for a whole system change. Finally, finding systematic ways to actively engage the voice of population groups, i.e. setting residents, themselves throughout the entire co-production endeavor is worthy of further exploration and development.

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