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# Promoting the health of vulnerable populations: Three steps towards a systems-based re-orientation of public health intervention research

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## ABSTRACT

This paper proposes a novel framework for the development of interventions in vulnerable populations. The framework combines a complex systems lens with syndemic theory. Whereas funding bodies, research organizations and reporting guidelines tend to encourage intervention research that (i) focuses on singular and pre-defined health outcomes, (ii) searches for generalizable cause-effect relationships, and (iii) aims to identify universally effective interventions, the paper suggests that a different direction is needed for addressing health inequities: We need to (i) start with exploratory analysis of population-level data, and (ii) invest in contextualized in-depth knowledge of the complex dynamics that produce health inequities in specific populations and settings, while we (iii) work with stakeholders at multiple levels to create change within systems.

## 1. Introduction

It is well documented that health is shaped by complex processes where social conditions play an important role (Diez Roux, 2011). Public health researchers and advocates continue to promote policies and actions on the social determinants of health (e.g. Carey and Crammond, 2015) and yet health inequities constitute one of the most persistent challenges to public health (Kelly-Irving et al., 2022). As defined by the WHO, ‘Social inequities in health are systematic differences in health status between different socio-economic groups. These inequities are socially produced (and therefore modifiable) and unfair’ (McCartney et al., 2019: 26).

Evidence from several systematic reviews has been summarized to suggest that we know too little of the effects of interventions in terms of reducing health inequities (e.g. Beauchamp et al., 2014; Boelsen-Robinson et al., 2015). As McGowan et al. (2021) point out, there is a clear need for more systematic collection of equity data in intervention research. The problem is not confined to issues of data collection,

however. In a secondary analysis of a Cochrane review of childhood obesity prevention interventions, Nobles et al. found that most interventions remain focused on downstream lifestyle factors (such as individual behaviors related to diet and physical activity), rather than addressing the wider social determinants of health (i.e. societal and environmental factors, such as taxation or regulations on air pollution) (Nobles et al., 2021).

This problem is known as lifestyle drift, i.e., “the tendency for policy to start off recognizing the need for action on upstream social determinants of health inequalities only to drift downstream to focus largely on individual lifestyle factors” (Popay et al., 2010: 148). Thus, a discrepancy exists between the focus of much intervention research on individual lifestyle and health behaviours and a broader body of research stressing the social and environmental causes of ill health (cf. Kelly and Russo, 2021; Sautkina et al., 2014).

However, even policies that do address the wider determinants of health might not be enough to tackle health inequities. Frohlich and Potvin (2008) argue that this kind of population-level approach, seeking

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to improve the health of the entire population, should be complemented with interventions that promote the health of socially vulnerable populations, i.e. groups of people that ‘share social characteristics that put them at higher risk of risks’ (ibid: 218; emphasis added). This is important, because population-level interventions tend to have socially differentiated effects and, in some cases, inadvertently exacerbate health inequities even if they lead to overall positive outcomes (ibid., cf. also [Katikireddi et al., 2021](#); [Kelly, 2010](#)).

As Frohlich & Potvin point out, vulnerable populations are exposed to multiple risk factors and co-morbidities that can be explained socially, e.g. in terms of low socio-economic position, poor living conditions, etc. In line with [Diderichsen et al. \(2019\)](#), vulnerability is not ascribed to individual characteristics, but to social processes that may result in increased exposure to various sorts of risk, along with increased susceptibility to adverse effects, and reduced capacity of responding through coping or adaptation (ibid.; cf. also [ten Have, 2016](#)). Thus, in order to address health inequities, public health interventions should attend to the more fundamental social and historical processes, which sustain ill health in vulnerable populations. Frohlich and Potvin provide a very general indication of the characteristics of such interventions, stating simply that they need to be intersectoral and participatory, and there is still a need to elucidate what it takes to foster equitable outcomes through interventions in socially vulnerable populations (see e.g. [Ten Have et al., 2021](#)).

We have recently argued that an important step towards understanding and intervening on complex public health phenomena such as health inequities is to systematically generate and integrate knowledge of the system(s) that give rise to these phenomena ([Rod et al., in press](#)). This involves the generation of knowledge of the patterns that emerge from complex systems, the mechanisms that produce them, and the dynamics that make them change over time (ibid.).

In this paper, we explore how intervention researchers in public health can pursue a systematic process of knowledge production that is designed specifically for the development of interventions that aim to reduce health inequities by promoting the health of vulnerable populations, and which incorporates attention to social factors and processes. We build on the recent update of the UK Medical Research Council (MRC) framework for complex interventions ([Skivington et al., 2021](#)), which recommends the uptake of a systems-based approach. In addition, we draw on the theory of syndemics which highlights the clustering and interaction between co-occurring social and health conditions which may lead to exacerbated outcomes within disadvantaged populations ([Singer et al., 2017](#)).

The MRC framework is structured around four phases of research: Development or identification of an intervention, feasibility, evaluation, and implementation ([Skivington et al., 2021](#)). We add to this by presenting a framework with three steps of knowledge production for the phase of ‘development or identification of interventions’ specifically for vulnerable populations. This framework should thus be seen as complementary to the MRC guidance, in so far as it specifies what a systems-based approach to intervention development in vulnerable populations would look like. Similarly, the three steps of knowledge production can be incorporated into other frameworks for intervention research, such as Intervention Mapping (Bartholomew [Eldridge et al., 2016](#)) or Wight et al.’s six steps in quality intervention development ([Wight et al., 2016](#)). We illustrate the three steps and discuss their implications for intervention research with reference to empirical research, using health inequities among children in high-income countries as an example.

### 1.1. Combining a complex systems lens with syndemic theory

Public health research is increasingly turning towards complex systems thinking for inspiration on how to handle complex health phenomena such as health inequities ([Rutter et al., 2017](#)). This approach can be seen as an extension of longstanding efforts in public health to

address the social determinants of health ([Dahlgren and Whitehead, 2021](#)) and to improve population health via structural and legislative change, such as smoking bans ([Frazer et al., 2016](#)). As demonstrated by [Bambra \(2021\)](#), macro-level policies and long-term political efforts are necessary to ‘level up’ social inequalities in the population at large.

However, complex systems thinking has important conceptual and methodological implications in so far as population health – and health inequities – are construed as emergent properties of complex adaptive systems. Essentially this means that health inequities are always in the making, and their persistent occurrence cannot be ascribed to one or more singular causes but should be seen as a result of ongoing and non-linear interactions between multiple and heterogeneous elements ([Diez Roux, 2011](#)). This multiplicity and heterogeneity operate at different levels of aggregation in time and space – from the individual to group and population levels. This means that even legislative change cannot be expected to have ‘magic bullet’ effects (cf. e.g. [Jarlstrup et al., 2022](#)), and that we need a more nuanced vocabulary than the upstream-downstream dichotomy ([Carey and Crammond, 2015](#)).

The updated MRC framework highlights some of these central properties of complex adaptive systems ([Skivington et al., 2021](#)). In [Table 1](#) we cite the framework’s definitions of three core concepts, while adding examples of our own to illustrate their implications for intervention research that specifically addresses health inequities.

As illustrated by the examples in [Table 1](#), the system properties of emergence, feedback and adaptation have important implications for public health interventions and for the ongoing reproduction of health inequities, even if it incorporates and extends insights from research on

**Table 1**  
Properties of complex adaptive systems – with examples relating to health inequities.

System properties (definitions from <a href="#">Skivington et al., 2021</a> )	Example
<i>Emergence:</i> Complex systems have emergent, often unanticipated, properties that are a feature of the system as a whole	Population-level smoking interventions have been successful in reducing overall smoking rates but have socially differentiated effects. This works in tandem with innovative marketing strategies and product development from the tobacco industry to create <i>emergent</i> patterns of nicotine use among young people that do not necessarily follow a socio-economic gradient (e.g. <a href="#">Wang et al., 2021</a> ).
<i>Feedback:</i> Where one change reinforces, promotes, balances, or diminishes another	During the COVID-19 pandemic, lockdowns in many countries meant that a large proportion of the population worked from home which lowered their risk of being infected. People in lower-paying jobs, such as staff in supermarkets, bus drivers, and cleaners who were unable to work from home, were more exposed to infections and, due to pre-existing socio-economic differences in health, they were also more likely to live with obesity or non-communicable diseases that would increase their risk of contracting complications. This can be described as a <i>feedback</i> mechanism resulting in inequitable COVID-19 related outcomes (e.g. <a href="#">Whitehead et al., 2021</a> ).
<i>Adaptation:</i> Change of system behaviour in response to an intervention	Introduction of healthy school canteens may not work as intended because of sustained fast-food consumption that builds on an <i>adaptive</i> relationship where social norms and the proximity of fast-food outlets to schools overrule the change introduced by school canteens ( <a href="#">Sawyer et al., 2021</a> ).

social determinants and policy-level interventions.

Within public health, systems-based intervention approaches have most prominently been applied in obesity prevention (Bagnall et al., 2019) and with promising, yet socially differentiated, results (Jacobs et al., 2021). When it comes to addressing health inequities they remain to be “operationalised in ways that generate relevant evidence or effective policies” (Rutter et al., 2017: 2602). A systematic review of complex systems approaches to chronic disease prevention identified health equity as a foundational aspiration in such work, but also found a lack of literature describing how this can be achieved in practice (Baugh Littlejohns and Wilson, 2019). In our view, such operationalization must explicitly recognize the clustering and interaction of diseases and risk factors in vulnerable populations as well as the role of social factors in shaping health inequities.

In this respect, the literature on syndemics offers theoretical support. Syndemics is defined as “the concentration and deleterious interaction of two or more diseases or other health conditions in a population, especially as a consequence of social inequality and the unjust exercise of power” (Singer, 2009, p. xv). This definition resonates well with Frohlich & Potvin’s arguments for a vulnerable population approach, but syndemic theory adds an important dimension by highlighting the exacerbated outcomes that may occur due to synergistic interaction between co-occurring health conditions. There are three criteria for a syndemic: “(1) two (or more) diseases or health conditions cluster within a specific population; (2) contextual and social factors create the conditions in which two (or more) diseases or health conditions cluster; and (3) the clustering of diseases results in adverse disease interaction, either biological or social or behavioural, increasing the health burden of affected populations.” (Singer et al., 2017).

The concept of syndemics has been applied in interdisciplinary examinations of co-occurring and synergistic epidemics in a range of contexts, most prominently in HIV/AIDS research (Pantalone et al., 2020) and research on syndemic diabetes (Mendenhall, 2019). The COVID-19 pandemic is also a case in point since the disease spreads and develops in synergistic interaction with other health conditions and in ways that are fundamentally shaped by the social environments where people live. This means that the COVID-19 pandemic under inequitable circumstances may acquire the characteristics of a syndemic (Mendenhall, 2020; Rod and Rod, 2021). Typically, studies of syndemics combine in-depth ethnographic fieldwork with surveys and/or epidemiological approaches that aim to identify and explain syndemic configurations of diseases and their social underpinnings within a specific population.

In Singer’s textbook introduction, syndemics is presented as a “critical systems approach” (Singer, 2009), and syndemic theory can thus be placed within the same epistemological umbrella as a complex systems approach to public health. This is also why we suggest syndemics as an analytical approach in the proposed framework, rather than, e.g., intersectionality. The concepts of intersectionality and syndemics are both concerned with explaining inequities as a result of co-occurring biosocial conditions, but they differ in their analytical starting points and emphases. Intersectionality implies a stronger focus on social categories (such as race, gender, and sexual identity), whereas syndemics starts from analyses of co-existing diseases and social problems (Sangaramoorthy and Benton, 2022). Nonetheless, syndemics does add a critical edge to public health intervention research: While systems-based approaches in public health emphasize the interaction between heterogeneous elements in general, syndemic theory provides a more specific focus on the synergistic interaction between co-occurring diseases and social factors. The role of power is reflected in the very definition of the syndemics concept, and the approach points inherently towards social and structural change as a necessary companion to health-related interventions.

Many studies and textbook chapters on syndemics provide recommendations relating to interventions and policy responses, but research that takes on the challenge of developing and evaluating syndemic

interventions is surprisingly sparse. This is, indeed, a clear weakness of the existing literature on syndemics. Singer argues that the syndemics perspective emphasizes the need to move ‘from siloes to systems’ (2009: 202) in order to address multiple and interacting causes of ill health and thus change the structural factors and policies in ways that may improve adverse conditions. Likewise, a separate section of Mendelhall’s ‘Rethinking diabetes’ (2019: 145ff) presents recommendations for syndemic interventions at several levels: Upstream policy solutions, clinical interventions, community interventions, and downstream solutions. Even though examples are given at each of these levels, more systematic intervention research is needed to move from analyses of syndemic configurations in specific populations to changes in policy and practice. This is why we see a great deal of potential in combining syndemic theory with the systems-based branch of public health intervention research that is currently being developed (Bagnall et al., 2019).

## 2. Three steps of knowledge production: identify, map, change

Based on a combination of a complex systems lens and syndemic theory we propose a framework with three steps for developing or identifying interventions aimed at promoting the health of vulnerable populations. Fig. 1 summarizes these three steps, their key rationales and guiding questions.

### 2.1. Step 1: Identify emergent patterns of vulnerability

Whereas most intervention research begins with the ambition of producing change in terms of one or more predefined health outcomes (which may be behavioral, such as smoking, or physical activity, as well as biomedical, such as obesity or specific diseases), we suggest a re-orientation towards a more holistic approach that begins by identifying and distinguishing between socially-defined populations where negative health outcomes cluster. In other words, patterns of vulnerability in identified groups take priority over specific diseases or singular outcomes. This entails analyses of population-level data to identify emergent patterns of vulnerability. This first step is systems-based in the sense that it defines vulnerability as an emergent property of a complex system, and it takes its cue from syndemic theory in so far as it aims to uncover clustering diseases or risk factors that co-occur within socially disadvantaged populations.

An example of such work is Rod et al.’s register-based study of childhood adversity among Danish children (Rod et al., 2020). In this study, data-driven cluster analysis was used to group children into five distinct trajectories related to adverse experiences of poverty and material deprivation, loss or threat of loss within the family, and aspects of family dynamics during childhood. The study identified a group of children with particularly high adversity, which clustered and accumulated over time. This socially vulnerable group consisted of three per cent of all Danish children, and children belonging to this group showed remarkably high rates of premature mortality (ibid.) and hospitalization across all ages and for a wide range of reasons, ranging from infectious diseases to injuries and mental and behavioral diagnoses compared to children with low adversity (Rod et al., 2021). This may indicate the existence of a syndemic even if the study did not specifically examine if or how these clustering adversities interact.

Whereas research of this type provides clear evidence of emergent patterns of vulnerability among children and documents a pressing public health problem, further analyses are needed before the problem can be addressed in intervention research. One option is linking such population data to geographical data. To illustrate this approach, Fig. 2 shows a case map of Denmark, where the adversity groups defined in Rod et al., (2020) are linked with the municipalities in which the children live at age 16. The map clearly shows that some municipalities have a higher concentration of children who experience an accumulation of adversities compared to others, which may help direct interventions towards areas with a high proportion of socially vulnerable children.

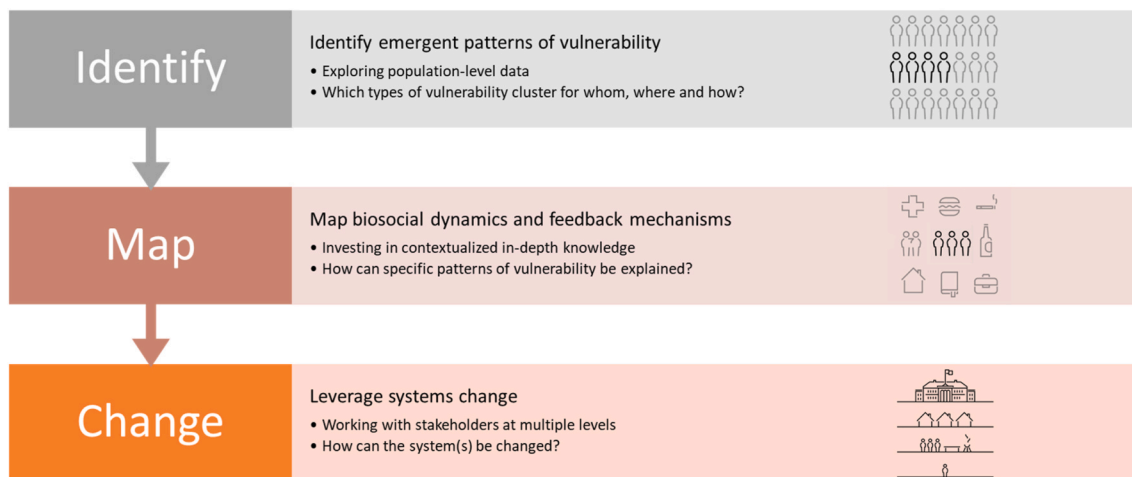


Fig. 1. Three steps of knowledge production for developing or identifying interventions in socially vulnerable populations.

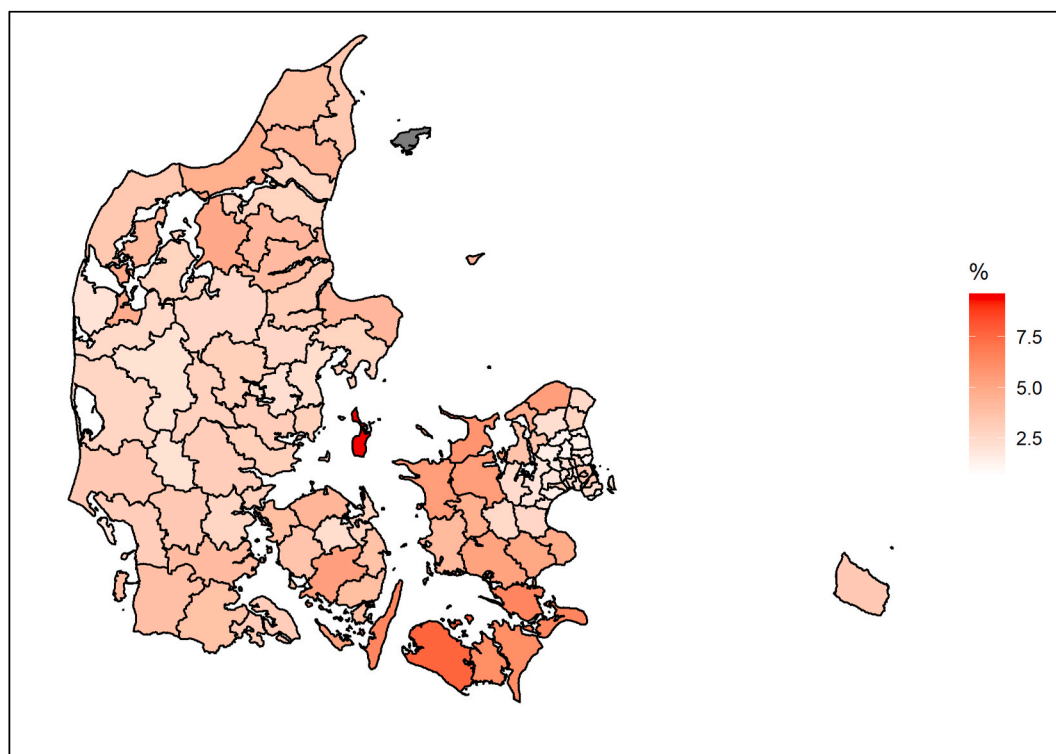


Fig. 2. The percentage of children (born 1991–1998) with accumulated adversity at age 16, by municipality. Based on data from Rod et al., (2020).

As this example illustrates, exploration of data can be used to identify settings and populations that are characterized by certain patterns of vulnerability. Identifying such patterns can help us operationalize the problem of health inequity and identify sites and target groups for intervention. It should be noted, though, that such data is not readily available for all populations, nor for all types of vulnerability. E.g., immigrant populations or homeless people tend to be underrepresented in health surveys and registries. Depending on the scope and research interests of the specific study, it may also be relevant to adopt qualitative methodologies in identifying patterns of vulnerability within a specific population or research site, and in syndemic research mixed-methods are frequently employed.

The main point here is to shift the conceptual starting point of public health intervention research away from specific health outcomes towards the identification of emergent patterns of vulnerability in socially

defined populations. In other words, a vulnerable population approach should begin by asking “Which types of vulnerability cluster for whom, how and where specifically?” rather than by defining vulnerability in terms of singular health-related outcome measures.

### 2.2. Step 2: Map biosocial dynamics

A great deal of public health research seeks to identify causal relationships that explain why inequities occur at a general population level. Most notably, social epidemiology has documented the role of social and environmental determinants (such as education, housing, and access to green spaces) for public health and health inequities (Diez Roux, 2022). To operationalize health equity for intervention research, however, we suggest a move from generalized knowledge of unilinear cause-and-effect relationships to more situated and contextualized forms

of knowledge.

Hence, the next step aims at unravelling the biosocial dynamics and mapping the mechanisms through which a specific pattern of vulnerability emerges within a population. This step is systems-based in the sense that it involves an examination of complex interplays between social and biological factors across different temporal and spatial scales. Syndemic theory serves as an analytical lens that encourages us to examine if there is any interaction between co-occurring diseases and risk factors which leads to exacerbated inequities. It also emphasizes the mutually reinforcing feedback that may occur between social conditions and health-related outcomes.

The emergence of certain patterns of vulnerability is shaped by larger-scale historical and political processes, at national as well as global levels, but syndemic theory reminds us that the specific dimensions and characteristics of vulnerabilities differ across contexts and localities (Mendenhall et al., 2022). Thus, following on from the above example of geographical differences in the proportion of children exposed to adversities in Denmark, a geo-ethnographic approach could be applied to explore the historical, political, economic and social variations between communities. Geo-ethnography uses geographical information system (GIS) data to identify sites for ethnographic fieldwork and has yielded interesting results, e.g. by elucidating the processes that lead to inequalities in gastrointestinal infections in UK families with small children (Rotheram et al., 2022).

More specifically illustrating the potentials of a syndemic approach, an ethnographic study of a former fishing village in the Netherlands examined how syndemic vulnerability was created across generations and could be explained by four interacting themes: social conditions, sociocultural normative processes, health behaviors, and adverse and early life events (Slagboom et al., 2022). By situating these themes in the historical and geographical context of this particular village, the study provides the kind of knowledge that is needed for intervention research to move from the identification of emergent patterns of vulnerability towards an understanding of the underlying biosocial dynamics. Looking for counter-syndemic processes, the study found that in some families syndemic vulnerability decreased over time due to a combination of educational attainment, continuous social support, and aspirational capabilities. This showed that in this case changing a single factor, such as education, is unlikely to be effective, and that a broader set of issues need to be addressed.

A promising approach for examining syndemics comes from complexity science and aims to identify the feedback mechanisms, or causal loops, that drive and reinforce health inequities over time (see e.g. Poon et al., 2022). In a US study of metabolic syndemics in rural minority communities, Apostolopoulos et al. (2018) showed how racial discrimination and rural deprivation worked in tandem as vicious circles that maintained ill metabolic health and low workforce productivity among rural Black Americans. Nonetheless, as Apostolopoulos et al. point out: “In response to deteriorating health among disadvantaged populations (e.g. increases in T2D prevalence among rural Black Americans), prevention programs and interventions have been predominantly low-leverage (e.g., behavioral interventions to improve dietary intake), overlooking the underlying and interconnected sociostructural mechanisms that have generated excess metabolic syndemic afflictions over time” (ibid: 1023). Thus, by mapping and modelling the role of causal feedback loops, complexity science can contribute to the identification of such interconnected biosocial mechanisms.

So, following the first step’s identification of an emergent pattern of vulnerability, the second step is concerned with the question: “How can specific patterns of vulnerability be explained?”. Due to the complex nature of the biosocial dynamics in which intervention research sets out to intervene, it is necessary to invest in contextualized, in-depth knowledge in order to answer this question, and we suggest that syndemics along with complexity science provide useful approaches for studies that may apply a wide range of methods. As an analytical lens, the concept of syndemics implies a dual focus on the interactions

between co-occurring health problems *and* on the role of social conditions, including power dynamics, in shaping syndemic vulnerabilities and ill health over time. For intervention research this provides a nuanced conceptualization of biosocial dynamics which helps concretize and narrow down the complexities that result in health inequities.

### 2.3. Step 3: Leverage systems change

As informed by syndemic theory, a vulnerable population approach calls for an intervention strategy that directly addresses the biosocial dynamics and feedback mechanisms that contribute to the (re-)production of health inequities. Identifying emergent patterns of vulnerability (step 1) and mapping the biosocial dynamics that (re-)produce health inequities (step 2) constitute necessary precursors to the development of interventions in vulnerable populations. As step 3, we propose that the aim of such interventions should be conceptualized as leveraging systems change.

An important implication of a systems-based approach is that interventions need to be assessed according to their abilities of producing systems-level change, i.e. the extent to which they disrupt the functioning of a system and thus change its emergent properties. As Carey and Crammond (2015) have pointed out: “When viewed through a systems lens, it is evident that the power of an intervention comes not from where it is targeted, but rather how it works to create change within the system” (ibid: 10).

As noted by Skivington et al. “Standardization of interventions could relate more to the underlying process and functions of the intervention than on the specific form of components delivered” (2021: 2). This means that systems-based interventions cannot be captured as a uniform and manualized set of actions to be implemented in a standardized manner across contexts. Instead, systems-based interventions can be described as systematic attempts at setting change in motion and building adaptive capacity at multiple levels.

In public health intervention research, so-called whole-system approaches are increasingly being adopted, most prominently in obesity prevention (Bagnall et al., 2019). Whole-system approaches can be defined as “those that consider the multifactorial drivers of obesity [and other complex public health challenges], involve transformative coordinated action across a broad range of disciplines and stakeholders, [and] operate across all levels of governance and throughout the life-course” (2019). Interventions that seek to leverage systems change build upon this type of work, but move beyond whole-system approaches by explicitly adopting a complex systems lens.

An example of such an approach is an ongoing program targeting childhood obesity in Amsterdam, where Sawyer et al. (2021) defined the working principles as follows.

1. “Multi-level action to address multiple, interacting factors influencing the outcome of interest within a specific context or population”
2. “Cross-sectoral working with diverse actors across government, public (academia, charity, community), and private organizations to develop and implement multilevel action”
3. “Capacity for responsive adaptation to achieve sustainable impact: action within a system must respond to emergent relationships which manifest due to systems change [...] Responsive adaptation could entail a change of program focus, implementation, or content” (ibid: 592)

As also observed by Sawyer et al., the two first principles are widely acknowledged and well-known elements of efforts to promote public health, but the third principle stands out and reflects a complex systems approach. The principle of responsive adaptation implies that a systems-based intervention approach should not be conceived as an isolated set (or “package”) of actions with predictable effects, but rather as an integral part of the complex, adaptive system which it seeks to change in a

particular direction (ibid.).

If we relate this principle to the previously mentioned example of childhood adversities, it becomes clear that interventions will need to adapt continuously to emergent patterns of vulnerability. Serving as a rather extreme example, periods of lockdown during the COVID-19 pandemic transformed the everyday lives of school children and created new patterns of vulnerability while making it more difficult for teachers and other professionals to identify and support children in need. More common fluctuations, e.g. in employment rates or food prices, will also leave their mark on families and communities and thus change the complex adaptive system of which interventions form part. Indeed, the creation of employment opportunities and reducing the costs of living might be conceived as important elements in a systems-based intervention approach.

An important characteristic of systems-based intervention approaches is that actions are co-created locally with a wide range of actors. In that respect, a complex systems lens can be seen as complementary to participatory health research in general (e.g. Rod et al., 2022). E.g., as part of the Amsterdam initiative, the LIKE programme was designed to promote healthy living and reduce obesity among 10-14-year-olds in a disadvantaged neighborhood (Waterlander et al., 2020). This involved formative research with adolescents, their families as well as societal stakeholders, such as schools, sport clubs, local government, and retail businesses. Applying a system dynamics approach, potential actions were identified based on causal loop diagrams that were informed by existing research evidence, qualitative research in the local community, as well as group model building sessions with local stakeholders (ibid.).

In the LIKE programme, the health outcome of obesity was used as the starting point for these processes and for setting the boundaries of the system(s) of interest. In contrast, by drawing on syndemic theory the present framework implies a broader focus on multiple health and social outcomes when defining system boundaries and mapping system dynamics. This provides a different framing of the local processes and may call for the involvement of a different group of stakeholders to identify and instill action on health and social conditions concurrently. E.g., in the case of childhood adversities, local co-creation processes could seek to strengthen the collaboration between social workers, teachers and community-based health professionals, while also aiming to identify and advocate relevant changes at a policy level in order to improve the underlying social conditions.

Apostolopoulos et al. (2018) have pointed to the potentials of engaging community stakeholders in the development of strategic plans that specifically seeks to change the dominant feedback loops that drive syndemic vulnerabilities. In a study of metabolic syndemics among Black Americans in rural areas, they identified two dominant feedback loops, related to racial discrimination and rural deprivation, and they employed system dynamics modelling to provide strategic guidance for preventive efforts addressing these issues.

Step 3 is thus concerned with the question “How can the system be changed?”. Not only in relation to health-related outcomes, but importantly also with regards to social conditions and the complex interactions between co-occurring diseases and risk factors that shape the lives of vulnerable populations. Intervention research adopting such a systems-based approach should seek to create change by working with stakeholders at multiple levels (from individuals, peer-groups and communities to local and national governments) and across multiple sectors (e.g. combining the resources of NGOs with governmental and professional practices in education, social work and health care). Importantly, this step also emphasizes the role of system dynamics and the need to continuously adapt interventions to ongoing systems-level change which makes the building of adaptive capacity across levels and sectors an essential element of intervention strategies. Further, syndemic theory reminds us that this is not simply a technical issue of capacity-building and collaboration, but essentially also about finding ways to instigate social and political change.

### 3. Conclusion

In this paper we suggest a framework consisting of three steps of knowledge production that provides a systems-based entry point for a vulnerable population intervention approach.

1. Identify emergent patterns of vulnerability in socially defined populations
2. Map the biosocial dynamics and feedback mechanisms that (re-) produce health inequities
3. Leverage systems change to produce equity in health

Obviously, this is not a complete roadmap to equity, but it suggests a re-orientation of public health intervention research that is intended to increase the relevance and hopefully also the success of this particular discipline in contributing to equitable change. The three steps must of course be translated and adapted to concrete situations, and they need to be complemented with considerations of research design, theory, and methodology.

Whereas funding bodies, research organizations and reporting guidelines tend to encourage intervention research that (i) focuses on singular and predefined health outcomes, (ii) searches for generalizable cause-effect relationships, and (iii) aims to identify universally effective interventions, the current framework suggests that a different direction is needed for addressing health inequities: We need to (i) start with exploratory analysis of population-level data, and (ii) invest in contextualized in-depth knowledge of the complex dynamics that produce health inequities in a specific population and/or setting, while we (iii) work with stakeholders at multiple levels to create change within systems.

We suggest that the framework can be used to complement current guidelines and frameworks for intervention development and evaluation, such as the MRC framework for complex interventions and Intervention Mapping, by providing guidance for the phase of developing or identifying interventions. It should be stressed, however, that intervention research is not as linear a process as the numbering of the three steps may suggest. It is, rather, an iterative process of trial-and-error and ongoing development and refinements of interventions as well as the processes of knowledge production. In addition, if we adopt a systems-based approach to the development of interventions, it will have implications for the ways we evaluate their feasibility, implementation and effects, according to the other three phases of the MRC framework. This raises important questions, e.g. related to the measurement of equity (Alonge and Peters, 2015) and the evaluation of interventions (Luna Pinzon et al., 2022; McGill et al., 2021), which go beyond the scope of the present paper.

In addition, it remains an important task for further research to identify the most potent leverage points for interventions addressing health inequities. Within the systems-oriented public health literature several frameworks have been developed which are concerned with identifying and assessing leverage points for change within systems (Bolton et al., 2022; Johnston et al., 2014; Nobles et al., 2021). E.g. Bolton et al. have proposed a framework with twelve leverage points for public health interventions based on Donatella Meadow's ‘12 places to act in a system’ (Bolton et al., 2022). A slightly simpler version, with only four levels, has been proposed by Nobles et al. (2021) who developed the Action Scales Model as a tool for policymakers, practitioners and researchers to evaluate actions and assess their abilities to transform how a system functions.

As Bolton et al. have suggested, the impact of an intervention is likely to be greater if it changes the overall paradigm according to which a system operates, rather than working with isolated elements (Bolton et al., 2022). In this paper, we have argued for the need to develop an intervention strategy that addresses the biosocial dynamics and feedback mechanisms which reproduce health inequities, and we have pointed to the potentials of adopting a systems-based intervention

approach that involves stakeholders across levels and sectors. When doing so, tools such as the Action Scales Model may be used to guide stakeholders in identifying various leverage points for change.

The identification and assessment of leverage points for change is related to a debate within the public health literature concerning the principle of proportionate universalism (Carey et al., 2015). This principle implies universalistic ideals, in line with the value of equity, which are coupled with a concern for the specific needs and characteristics of various population groups which may call for 'proportionate investment of resources' (ibid.). Within this debate it remains contested if and how particular groups should be targeted with specific types of interventions, due to the inherent risks of further marginalization and stigmatization. From a systems-oriented point of view, it becomes imperative to examine the interplays between various levers of change, such as universal and targeted interventions, as well as to evaluate the unintended and potentially undesired consequences that are more likely than not to occur along the way. There is, of course, no guarantee that the use of systems-oriented frameworks, such as the one proposed in this paper, will lead to reduced inequities. In some respects, we are reiterating classic insights from decades of public health research that political, structural, and cultural changes are required to improve population health. Further, by highlighting the role of biosocial mechanisms, the proposed framework complements and details earlier sociological work that describes inequities as products of 'higher-order social structures' (Kelly and Russo, 2018, 2022). Medical sociology has illuminated how social processes and structures (broadly construed as to include issues of power) affect health and disease, but by and large this literature has not detailed the concrete pathways through which social forces affect health and disease.

Thus, the novelty and contribution of the framework lie in the integration of theoretical insights from the social sciences with a complex systems lens and a stepwise intervention development approach. Specifically, the framework incorporates syndemic theory as an analytical lens, but sources of inspiration may also be found in theories of social practice (Kelly and Russo, 2018), intersectionality (Sangar-amoorthy and Benton, 2022) or embodiment (Kelly-Irving and Del-pierre, 2021). As previously mentioned, the existing literature on syndemics is rather weak when it comes to identifying and/or developing interventions, and it is course important to consider if other theories or conceptual approaches would be more helpful for a specific study. Nevertheless, the framework does call for the development of theoretically grounded understandings of the biosocial mechanisms that explain the reproduction of inequities in specific contexts. A growing body of literature deals with the application of systems thinking and complexity science in public health intervention research. However, as Baugh Littlejohns & Wilson (2019) indicate, this literature is not very explicit about the processes through which systems are delineated and boundaries are established, e.g. relating to the inclusion of particular sets of actors in processes of intervention research. We thus suggest that intervention research is systematically accompanied with so-called *boundary critique*.

The term boundary critique comes from critical systems thinking and it refers to the boundary judgments that establish which facts and norms are considered relevant in a particular situation (Ulrich, 2003). E.g., in the present paper we make a boundary judgment by suggesting that the intervention objective should be delineated based on a vulnerable population approach, rather than predefined health outcomes. Similarly, despite the holistic aspirations of whole-system interventions, choices need to be made regarding the delineation of systems, the involvement of particular groups of people, and the types of knowledge that is considered relevant.

According to Ulrich, "systemic boundary critique is an indispensable principle of any applied discipline" (2003: 339). He criticizes the application of systems approaches in various fields of applied science for being overly instrumentalist and for ignoring the tacit assumptions and value judgments that are involved in such work. Baugh Littlejohns &

Wilson translates this concern into the following questions which are related directly to public health intervention research.

- > "whose interests are/should be served [...] and what might the consequences be?"
- > who are/ought be the decision makers [...] and what resources and measures of success do they have control over?"
- > who is/should be involved as provider of evidence and experience?"
- > who is/should be considered legitimate stakeholders or actors and what diverse perspectives or worldviews are/should be considered?" (2019: 9)

Boundary critique is an ongoing reflexive practice that should be considered integral to the responsive adaptation that characterizes systems-based intervention approaches. It reminds us that health equity is, in itself, a value-laden concept and that our interventions imply judgments of the types of differences we consider "unfair, avoidable or remediable" (Whitehead, 1992) as well as the types of change we render possible.

### Declaration of competing interest

None.

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