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Studies indicate that most noncommunicable diseases (NCDs) are linked to various degrees to lifestyle and behavioral risk factors (McGinnis and Foege 1994; Mokdad et al. 2004). Logically, it follows that NCDs and associated mortality, morbidity, and other social costs can be prevented through decreasing the population prevalence of those risk factors (Smedley and Syme 2000). In this chapter, we argue that because of the complexity of the ecosystems that shape the population prevalence of NCD risk factors, there is still much uncertainty about which actions are required by whom to influence the population prevalence of risk factors.

Current etiological models, even the most complex ones, are limited to identifying potential causal pathways that go from ecosystemic conditions to population prevalence of risk factors to morbidity and mortality. For example, the systemic model of the obesity system developed for the British Foresight Report on obesity maps several dozens of variables and their feedback loops, into a very complex graphic representation (Government Office of Science 2007). Strength of this and other similar models is that they represent vital and necessary knowledge for identifying the risk factors and conditions that should be targeted

by public health programs and policy. They offer a variety of intervention points for public health and other actors in the prevention arena. Their major weakness however is that they provide very little clue on how to modify those conditions: on the type of public health programs and policy that should be implemented, by whom, where, and how, in order to affect those conditions and achieve foreseeable population health goals. Other types of studies and scientific efforts are required for that, studies that aim to develop a body of knowledge about the implementation and effectiveness of policy and programs aimed at changing the population distribution of risk factors and conditions involved in the etiology of NCDs.

The Moving Target of NCD Prevention: The Example of Tobacco

The spectacular reduction of tobacco consumption achieved in North America and in most Northern European countries during the last quarter of the twentieth century is often recognized as one of the major victories of public health. Indeed, starting in the late 1960s, and following the US Surgeon General's report on the adverse health consequences of tobacco smoking (US Department of Education, Health, and Welfare 1964), a wide variety of smoking cessation and tobacco use prevention efforts have been tried, implemented, disseminated, and scaled up. As of the end of 2012, the Cochrane Tobacco

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Addiction Group (www.cochrane.tobacco.org) has published more than 70 review reports on tobacco prevention, smoking cessation, and government policy, synthesizing results from hundreds of interventions.

Since the 1970s, the use of tobacco has declined steadily in most western countries (Schaap et al. 2008). This decline was accompanied by a decrease in cardiovascular mortality for which smoking is one of the major risk factors (Unal et al. 2003). It is estimated that the 32 % reduction in smoking prevalence in the USA between 1980 and 2000 was responsible for 12 % of all the deaths from coronary heart diseases that were prevented in the USA during that same period (Ford et al. 2007). Overall, it is estimated that about 50 % of the reduction in coronary heart disease mortality during the last quarter of the twentieth century in developed countries can be attributed to the reduction of behavioral risk factors (Ford et al. 2007). Such data confirms some of the early promises of epidemiology that the identification of modifiable risk factors would lead to the reduction of their prevalence and ultimately to preventing diseases, suffering, and death.

However, a deeper examination of global trends in tobacco consumption shows that there is still much to accomplish for the prevention of tobacco-related mortality. After almost 50 years of efforts, tobacco is still killing on a massive scale globally (Ezzati and Lopez 2003; Jha 2009). In Western countries, where most of the prevention efforts have taken place and where significant reduction in tobacco consumption was achieved, the prevalence of smokers seems to stagnate somewhere between 15 and 25 %, (OECD 2009). More preoccupying is the fact that in all countries for which data is available, those who have stopped smoking are more likely to be from higher socioeconomic groups (Schaap et al. 2008). Consequently, the prevalence of smokers is now much higher among individuals in lower socioeconomic status groups (Barbeau et al. 2004), and more difficult to reach by standard cessation programs and tobacco reduction policy. In addition, the reduction of smoking in Western countries was accompanied by a displacement of the tobacco industry's marketing efforts which are now concentrated in regions of emerging economies, especially in

Eastern Europe and Asia (Gilmore and McKee 2004). Drawing lessons from the tobacco prevention policies and programs in Western countries, the tobacco industry adjusted its practices to develop new markets. "As the transnational tobacco companies successfully established new markets, they adapted aggressive marketing strategies used in high-income countries. Many of these strategies are illegal or severely restricted in high-income countries" (Lee et al. 2012, p. 117). Nowadays, 80 % of smokers reside in low- and middle-income countries and about 50 % of smoking-related deaths are occurring in low-income countries (Jha 2009). The tobacco epidemic has gone global (Proctor 2004) and has become a marker of social health inequalities (Frohlich 2008).

This example illustrates what becomes increasingly clear for epidemiologists and public health practitioners: the social conditions that shape population prevalence of risk factors (Rose 1992) are complex, multifaceted, and made of interrelated systems. Attempts to modify some of those conditions in populations through policy and programs may have impacts well beyond the conditions that were targeted by those interventions. Epidemiologists, and social epidemiologists in particular, have criticized etiological models of disease causation that propose a linear representation, from distal to proximal, of chains of causes (Krieger 1994, 2008). Instead, they propose models that take into account all aspects that influence human lives, from biology to the ways in which societies are organized (Dahlgren and Whitehead 1991; Mackenbach and Stronks 2004; World Health Organization 2008). For public health practitioners, these complex and multilevel models often translate into an ecological or an ecosystemic approach to chronic disease prevention (Richard et al. 2011; Institute of Medicine 2002) as a way of dealing with the complexity of the social world.

The Ecological Paradigm and the Context of Prevention Interventions

In the 2002 report on the *Future of the Public's Health in the 21st Century*, the Institute of Medicine (2002) strongly suggested the use of

the ecological model for the planning and implementation of prevention. Ecological model recognizes that population prevalence of chronic diseases is rooted in the complex interplay of conditions that run across the many systems that form a society. To be effective prevention should encompass this complexity. There exist many variations and formulations of the ecological model for health (Richard et al. 2011). Typically these models represent individuals' behaviors and their determinants within their context and in interaction with the context as well (Trickett 2009). Ecological models conceive of individuals' behavioral risk factors as being influenced by the many systems and subsystems in which they belong and interact with other individuals throughout their life course. These systems vary in size, from household and family to workplace, to community, and to nation. In many representations, each system is embedded into a more inclusive, higher level system. Furthermore, since higher level systems are social settings, an ecological perspective on health also encompasses the so-called social determinants of health (WHO 2008). Therefore, ecological interventions to reduce the prevalence of risk factors in a population are generally comprehensive and multi-strategical (Institute of Medicine 2012). They seek to implement activities aimed at modifying environmental and social conditions in multiple relevant settings and these activities encompass a variety of strategies through which environments can be modified (Richard et al. 1996).

The actual WHO global strategy for addressing the tobacco epidemic, the Tobacco Free Initiative (WHO 2012a), is an example of the application of a comprehensive ecological model. At the core of this initiative, the MPOWER strategy proposes six types of activities that comprise most of the known effective interventions to reduce smoking prevalence. These are the following: (1) monitor tobacco use and prevention policies; (2) protect people from tobacco smoke; (3) offer help to quit tobacco use; (4) warn about the dangers of tobacco; (5) enforce bans on tobacco advertising, promotion, and sponsorship; and (6) raise taxes on tobacco (WHO 2012b).

One prominent feature of the ecological paradigm for prevention is the integration of a systemic perspective (Green et al. 1996; Stokols 1996; McLaren and Hawe 2005). Populations live in, and create, ecosystems composed of interrelated subsystems which include all the elements of the social and physical environments that support life. By definition, such systems are open systems, meaning that changes in any subsystem impact other subsystems through a series of feedback loops that characterize systems' functioning (Richard et al. 2011). Likewise, comprehensive population- and community-based prevention interventions are increasingly conceived as systems operating within those ecosystems (Hawe et al. 2009; Potvin and McQueen 2008; Trickett 2009), implying also reciprocal feedback loops between the interventions and the contexts in which they are implemented. In other words, population-based prevention interventions are not just a series of activities that are planned and implemented with resources that are totally situated outside of the setting of interest. These activities form systems of action that may or may not be resourced from external sources but are supported by delivery systems that engage with the community in which they are implemented (IOM 2012; Poland et al. 2008). To effectively change conditions that shape the prevalence of risk factors, prevention strategies must be culturally relevant and adapted to the characteristics of the settings (populations and communities) in which they are implemented (Trickett 2009) and they must be supported by some participatory mechanisms that engage with local populations (Viswanathan et al. 2004).

Context and the dense network of interactions among the various environments that compose one's context are increasingly recognized as fundamental elements, not only for understanding the population distribution of NCDs but also in the design and implementation of prevention efforts and in their evaluation (IOM 2012; Poland et al. 2008). Dealing with context in the implementation of prevention has become one of the major challenges not only in the design and implementation of NCD prevention but also in the constitution of a body of scientific

knowledge to inform prevention (Potvin et al. 2005; Ruetten and Gelius 2011). Prevention interventions, in the form of policy or programs, can no longer be conceived as coming entirely from outside of the population concerned. Although there is some kind of externality in terms of resources, knowledge, and practices that are associated with NCD prevention, the manner in which such external elements are adapted and integrated in context is seen as constitutive of the effectiveness of such interventions (Poland et al. 2008; Trickett 2009).

This raises fundamental questions about the traditional neglect of issues related to external validity in health sciences and about the relevance and limitations of generalizing the results of population health intervention experimentations across settings (Green 2006; Green and Glasgow 2006). If adaptation and intervention–context interactions are essential elements for intervention effectiveness, then knowledge derived from experimentations in prevention can only be considered as the best plausible hypothesis for designing and implementing prevention in another setting. Indeed, beyond the mere recognition that implementation variations exist across sites not much is known about what produces local implementation variations of prevention policy and programs (Clavier et al. 2012a, b), and how to adapt those programs as a function of the various contexts, in order to maximize effectiveness. Aggregating empirical results from intervention experimentations across settings is unlikely to provide insights into how interventions interact with context and what makes those interactions effective. As a complement to epidemiology—a science that illuminates problems, their prevalence, and their causes and which provides invaluable knowledge about the causal pathways that lead to the population prevalence of NCDs—there is a need for developing a science of solutions that will provide valid scientific knowledge on the design, implementation, sustainability, diffusion, and scaling up of prevention efforts and their variations. This is exactly the goal of the nascent field of population health intervention research.

Beyond Evaluation: Population Health Intervention Research

There is a rich and productive field of research called evaluation that has been thriving for almost half a century. Rooted in the “Great society” objectives of the 1960s, early developments in the field of evaluation were linked to the ambitious program of using scientific means to transform society for the public’s good (O’Connor 1995). The “experimenting society” as one of the pioneering figure of this field explained would be continuously studying attempts to improve social conditions and use the knowledge produced to inform further improvements (Campbell 1969, 1991). During the past decades, evaluation has developed as a scientific field, with its own journals, professional associations, and graduate training programs. The interventions evaluated cover a wide range of social, health, and economic issues at scales that vary from individual to global. Because it is also closely associated with judging the value of interventions and decision making, the field of program evaluation has often been discussed as a planning and management tool instead of a scientific endeavor.

In health research particularly, the term evaluation is not widely used to discuss the development of knowledge concerning interventions. In medicine and other health professions, clinical epidemiology has become the science through which knowledge about practice and clinical interventions is developed, synthesized, and disseminated into evidence-based practice (Sackett et al. 1985). There is now a general consensus about the distinction between epidemiology as a science that seeks to describe and understand the distribution and causes of diseases and clinical epidemiology, the study of clinical practices that relates to diagnosis and therapy in the context of patient care (Sackett 2002).

In the field of population and public health there is an analogous attempt to distinguish between research focusing on the causes of the population distribution of diseases and risk factors and research focusing on the interventions that are developed and implemented in attempts

to modify these distributions through changes in social and physical environment. Population health intervention research (PHIR) is defined as the use of scientific methods to produce knowledge about interventions designed and implemented within or outside of the health sector with the intention to change the distribution of health and its determinants in a population (Hawe and Potvin 2009). Although there are many areas of overlap between PHIR and evaluation, the former appears as a specific subfield for population and public health and clearly identifies a specific object (population health intervention) for scientific enquiries. Hawe and Potvin (2009) further define population health interventions as coordinated actions, in the form of policy or programs intended to change the conditions that shape population health. Morabia and Costanza (2012) noted the overlap between the conceptual and methodological territory claimed by PHIR and the US-based tradition of community intervention research. The latter, a typical multidisciplinary field in which public health and community psychology researchers have been very active, is generally defined as the study of community-based interventions aimed at disease prevention and at the promotion of community well-being.

In population and public health, early attempts in the 1980s and 1990s to “experiment” with, and change, the social and community conditions that shape behavioral risk factors and ultimately, population health, were mainly undertaken by academic researchers to test scientific hypotheses. The Stanford Five City Project (Fortmann et al. 1995), the Minnesota Heart Health Project (Luepker et al. 1994), the Kaiser Family Foundation Community Health Promotion Grant Program (Wagner et al. 2000), and the tobacco prevention COMMIT trial (COMMIT Research Group 1995) are examples of such community trials designed and implemented by academic researchers. It became clear in the late studies such as the Kaiser Family Foundation and the COMMIT trial that in order to be effective community interventions need to be flexible and adaptations to contextual conditions are necessary. Relevant questions for such trials were no longer

whether community approaches to prevention work but instead what mix of activities is likely to be effective in which context (Fisher 1995), shifting the emphasis away from the intervention itself towards local capacity to implement and sustain interventions. This coincided with an increasing preoccupation with the sustainability of such initiatives once the research project is completed, making important distinctions between intervention delivery systems that are created through research projects and community service delivery systems that are the vehicle through which such projects can be continued and sustained (Altman 1995). Indeed, one important caveat associated with early community prevention trials was that even in the case of effective interventions, delivery systems created through research funding that were mainly serving research objectives were not necessarily transferred nor transferable to existing community structures.

In the same manner that clinical epidemiology is now an important contributor to the improvement of therapeutic practices in clinical settings, we suggest that population health intervention research will provide critical knowledge for evidence-based NCD prevention. Most robust research findings in clinical epidemiology come from studies that take place within regular care delivery systems with regular clinicians. In many cases research is integrated within care delivery systems and such integration has been shown to increase the relevance of research for practice, increase innovation in practice, and decrease the lag between scientific discovery and improvement in clinical practice. This proximity between research and delivery systems is even more critical for the nascent field of PHIR in which intervention context plays a dual role. First, as implied by the systemic ecological model, the effectiveness of population interventions is linked to the manner in which interventions adapt and are made relevant with regard to local conditions. Second, as community prevention trials have shown, delivery systems created for supporting community interventions driven and funded by research are not sustainable once research is over nor are they directly transferable to other communities.

The Role of Context in PHIR

As objects of scientific inquiries, population health interventions can, and should, be studied using a variety of questions. From an evidence-informed practice perspective, we suggest that with regard to a problematic issue in population health, and given that there is sufficient knowledge about the causal web of risk factors and social determinants at the root of the problem, several relevant questions need to be formulated to guide research on how to modify the distribution of those risk factors and social determinants in the population. Table 13.1 presents a typology of research questions that can potentially be addressed with regard to potential interventions.

The first type of question is concerned with the hypothetical exploration of what could work to modify the conditions that shape the distributions of given risk factors in the population. Providing valid answers to this type of questions implies a theoretical or an empirical exploration of potential solutions for a defined problem. Theoretical exploration entails the use of one or several social change theories in order to design an intervention that would translate relevant theoretical principles into actions. The empirical exploration of potential interventions by scientific means entails developing synthetic reviews of interventions that have been designed and studied to address an issue that is similar to the one at hand. This exploratory work results in aggregating the intervention effects

across contexts in order to derive average effects that constitute the best effective hypothesis for any given context. Indeed, statistical inference works only in one direction, from the sample to the population. It is the role of the researcher to make the case that the particular context in which effective interventions are to be implemented belongs to the same “population” of contexts for which an intervention has demonstrated effects. Even when this is the case, cultural adaptations still need to be developed, and it is the task of the implementation system to operate and integrate those adaptations.

All the following questions are concerned with specific interventions. One weakness often mentioned when dealing with population health intervention research is the lack of relevant implementation details in most intervention descriptions (Egan et al. 2009). Furthermore, there is no generally agreed definition of what constitute such interventions, what they are made of, and what makes them effective. For Hawe, Shiell, and Riley (2004) for example, it is not so much the specific activities that form the important components of an intervention but rather it is the social mechanisms that these activities are triggering. The activities (or events) that form the observable, empirical elements of any given intervention are indeed context bound and result from interactions between interventionists’ objectives and resources, the mechanisms that need to be triggered to operate the desired changes in risk factor prevalence, and the conditions in the local context (Hawe et al. 2009; Potvin et al. 2012).

Table 13.1 Typology of research questions in relation to population health interventions

Type of question	Methodological recommendations to provide valid answer
What could work?	Theoretical exploration of potential interventions given actual state of knowledge Synthetic review of existing studies on interventions that addressed same or similar issues
Could “it” work?	Trial of specific interventions in controlled conditions with adequate counterfactual
Does “it” work?	Observation of the chain of effects (proximate, intermediary, and distal) that follow an intervention implemented with contextual constraints
How does “it” work?	Observation of the interactions between context and intervention that produce (or not) the intended chain of effects
Is “it” sustainable/replicable/scalable?	Observation of an intervention’s capacity to produce similar chains of effects through time and in other contexts

The second type of questions pertains to intervention's efficacy. It concerns an intervention's potential effects when it is implemented in ideal conditions. Following an experimental design, the intervention is randomly assigned to ecological units that come from the same population. Contextual conditions are controlled for in attempts to isolate the intervention as the main cause of observed changes. In a classic experiment, delivery systems that insure fidelity in program implementation are juxtaposed to or simply replace existing local systems. This was the case for the Catch Study (Perry et al. 1990) in which 96 primary schools in four states were randomly assigned in either of the three arms, two experimental and one control. In schools from the two experimental arms, intervention activities and classroom curriculums developed by researchers were implemented under the close supervision of researchers, leaving little room for local adaptation. In another type of experiment, the Kaiser Family Foundation Health Promotion Program has randomly assigned volunteer communities to receiving resources and training to develop activities to increase community activation in order to address issues that were identified locally (Wickizer et al. 1998). In this case, local conditions were not controlled for but their interactions with the intervening mechanisms resulted in variations in the activities implemented by local service delivery systems with the support of resources provided by the research.

The third, fourth, and fifth type of questions all concern the study of interventions implemented through local service delivery systems in response to local issues. In all those cases, intervention is designed mainly by professionals and the role of research is to accompany the intervention without attempting to control and impose intervention activities or mechanisms at play. In such cases, it is hypothesized that interventions are going to be responsive to contextual conditions and that their form will evolve with the changing contextual conditions (Potvin et al. 2001). Research is not testing specific preestablished intervention hypothesis but it deploys observational methods, with or without a control group, to analyze and understand the conditions

that shape the intervention's activities as they unfold, as well as their effect on a variety of potential outcomes (Potvin and Bisset 2008). Most of the evidence regarding the effect of tobacco prevention interventions at the population level was derived from observational data analyzed by researchers who were following interventions implemented by regular service delivery systems (Hopkins et al. 2001).

There is still a healthy debate in the public health literature about the superiority of the randomized controlled cluster trial to derive evidence about whether an intervention is producing a desired effect (Fuller and Potvin 2012; Macintyre 2011). It is not the intention of this chapter to enter into this debate. What needs to be recognized from the perspective of population health intervention research is the variety of questions that can legitimately be addressed to build a knowledge base about population health interventions. Many of these questions require the use of observational methods. In fact, whenever one is trying to open the black box of complex interventions and to understand how these interventions are producing effects, and how these effects can be reproduced through time (sustainability) and across settings (diffusion and scalability), one does not have much choice but to use observational methods that can also be implemented as complementary to randomized trial (Corrigan et al. 2006).

PHIR and Implementation Systems

Population-based NCD prevention requires implementation systems that can support complex, systemic interventions that are continuously adapted to local conditions. True to ecological approach, and recognizing that the health sector alone does not control the levers by which most social determinants can be modified (Institute of Medicine 2002; WHO 2010), such systems are usually composed of numerous stakeholders with a variety of roles the health system alone is not able to fulfill. As exemplified in Fig. 13.1, activities, services, and policies are the result of interactions and sharing of resources between those

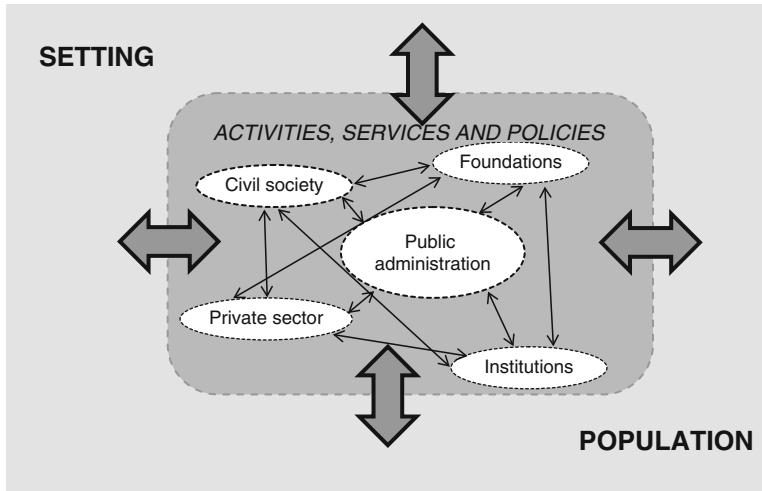


Fig. 13.1 Implementation system for population health interventions

stakeholders. The dotted lines representing the contours of the various structures indicate the permeability and numerous exchanges between context, the various stakeholders, and the systems created to support interventions (Potvin and McQueen 2008). The double arrows between the setting and the intervention system indicate that they coevolve, changes in local conditions inducing changes in the intervention and effective interventions producing changes in settings (Potvin et al. 2001).

As illustrated in Fig. 13.2, research on population health interventions developed and implemented by service implementation systems requires that a research infrastructure be coupled with the intervention system. This research apparatus may vary in size and complexity but ideally in addition to population health research capacity there should be some liaison capacity that facilitates both the translation of practice problems into researchable scientific questions and the communication of research results into actionable conclusions (Clavier et al. 2012a, b). Critically, as illustrated in Fig. 13.2, this coupling of research with implementation system provides the latter with a communication channel with the research sector which facilitates access to scientific knowledge. It also facilitates reflexivity of practice as a means to reveal how intervention is shaped by contextual conditions

in interactions with practitioners and other partners' motivations and theoretical underpinnings (McQueen 2007). Organized reflexivity (Potvin and Bisset 2008; Potvin et al. 2010) is a type of evaluation practice that aims to illuminate conditions that allow an intervention to be produced and reproduced, and to situate its components and results, in context.

Another implication of Fig. 13.2 is that all components of the intervention and their interactions with the implementation system are potentially relevant for research. A comprehensive knowledge base on population health interventions would provide scientific knowledge about whether an intervention works but also how effects are produced, for whom, and in which conditions. Potvin, Haddad, and Frohlich (2001) list five families of questions that go beyond the usual dichotomy between outcome and process evaluation. The questions pertain to relevance and ways to ensure that an intervention addresses an issue that is real for the concerned populations; coherence between the intervention's objectives and actions and their adaptation to local culture; the intervention's achievements or how actions are produced, including conditions of scaling up, dissemination, and sustainability; the intervention's effects and impact; and the intervention's responsiveness to local conditions through its evolution.

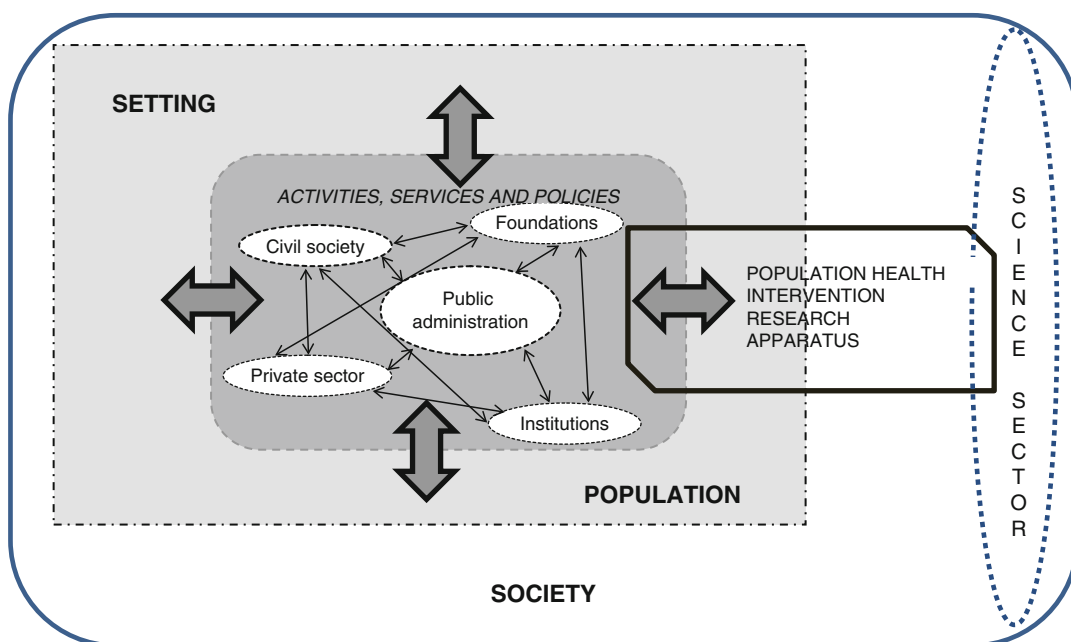


Fig. 13.2 Relationship between PHIR apparatus and implementation system

Conclusion

Attempts to change the distribution of risk factors and the social determinants of NCDs require complex population health interventions that mobilize actors from many sectors who implement a variety of activities that potentially affect many systems that shape these distributions. Because of their complexity and their necessary adaptation to local conditions, there are large areas of uncertainty with regard to how these interventions interact with implementation context. For many of these comprehensive intervention strategies the possibility of harmful and undesirable effects is still present. Prevention interventions are thus still largely based on trials and errors informed by previously evaluated trials.

Most of the actual research in prevention aims at identifying risk factors and their specific pathways and contributions to NCDs. In this chapter we have argued that progress in evidence-based prevention will be linked to the development of a science of population health intervention. Such a science would aim at developing scientific knowledge bases for such interventions and that could be used to

develop theoretical propositions about the planning, implementation, diffusion/sustainability/scaling up, and evaluation of such interventions. Furthermore, to be relevant and contribute to NCD prevention, a large proportion of studies should be conducted about practices, programs, and policies planned and implemented by public health service delivery systems in order to identify which interventions work, how they work, for whom, and under which conditions. Not only would the development of such research infrastructure allow the development of badly needed knowledge, but it also increases service delivery implementation systems' reflexivity. This in turn should theoretically increase the effectiveness of prevention.

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