

TOWARDS SYSTEMS THINKING: STRENGTHENING THE BONDS BETWEEN OPERATIONS RESEARCH (OR) AND HEALTH SERVICES PLANNING & EPIDEMIOLOGY

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ABSTRACT

The study proposes a dialogical approach between OR and Health Services Planning and Epidemiology based on the similarities of their own epistemological experiences, according to Habermas' Theory of Knowledge. As a field of application, health services planning and epidemiology are Complex Societal Problems (CSP), requiring multidisciplinary and multi-dimensional approach. The paper suggests an agenda towards systems thinking to enhance the interaction between the disciplines to guarantee the implementation research' results by decision makers. Multi-methodology and concept maps tools deal with CSP and may consider peacefully the coexistence of different paradigms. Structuring the problems by concept maps accomplish the systems thinking approach, by presenting the context with diverse levels, feedback loops and dependencies. The map is a real board upon which actors and stakeholders exercise their communicative skills and define collaborative loops towards concepts, meanings and practical implementation.

Keywords: epistemology; systems thinking; soft OR; complex societal problems; health planning; epidemiology.

1. INTRODUCTION

There is much criticism concerning approaches to OR health care that look for databases aiming to feed a mathematical model and disregarding significant societal contexts. Besides, the easiness for development and spread of simulation and optimization software has generated many scientific publications that, when presenting results detached from reality, contribute to weaken the reliability of these important and useful tools to solve complex societal problems (CSP), as is the case of health services planning and evaluation (Hollingsworth,2008).

The present study tries to unfold this problem and propose a dialogical approach between the two different disciplines involved in this correspondence: OR and health services research epidemiology, to enhance its usefulness and validity. That is, if we intend to apply the operations research scientific discipline to solve problems related to the field of health services planning policy, we need to discuss the state of art of their

own postulates, conclusions, cognitive validity, structural paradigms and the relationship with society and history. This epistemological first step is an appropriate way to guarantee the acceptance of the results by the scientific community related to the field of application (health professionals and managers, in this case). In summary, before any application, we need to know if the scientific disciplines are speaking the same language; and to look for ways of convergence of their priorities and different points of view, while searching for complementary bonds.

In the second section, we present a summary of the epistemological developments following Ackoff's seminal questioning on the social role of the OR discipline, its deviance from the "real world" priorities and its limitation for solving dynamic and complex societal problems (Ackoff, 1979a).

The third section will present the state of art of epidemiology and health planning, especially with respect to their role for informing and implementing health policies in Latin America.

The correspondence between OR, epidemiology and health planning and the similarities of their own epistemological features will be summarized in the fourth section.

After this encounter and synthesis, the fifth section will characterize health as a complex societal problem and present an agenda for a multidisciplinary health services research based on multimethodology, concept maps and systems thinking approaches.

2. GENERAL FOUNDATIONS FOR OPERATIONS RESEARCH APPLICATIONS: THE FUTURE OF OR IS NOT PAST.

According to Rosenhead's definition (2001), OR is a "process of offering aid to organizational decision making through the construction of a model representing the interaction of relevant factors, which can be used to clarify the implications of choice".

As pointed by Gass & Assad (2005): "As implied by its dictionary definition, OR's distinguishing characteristic is that OR applies its scientific and technological base to resolving problems in which the human element is an active participant. As such, OR is the science of decision making, the science of choice". This emphasis opens fundamental questions regarding not only a multidisciplinary, but also a multiple perspectives/multiple agents approach.

The discipline was first developed in the 30's, as an essentially applied science, initially used to aid military decision making, based mainly on simulation and linear programming techniques. Thereafter was highly adopted by administrative circles and corporations (until the 60's, along with the academic and managerial dissemination of the discipline, it was called the "golden age" of OR; Kirby, 2007).

In the 70's, an internal criticism appeared inside the OR community, as published by Hall & Hess (1978, "OR/MS Dead or Dying? RX for Survival" *apud* Ackoff, 1999), who suggested to reinforce the bond between academic and non-academic practitioners, and by Tosher (1977, *apud* Ackoff, 1999), who proposed a more profound disciplinary change by questioning the suitability for the paradigm of OR at that moment to solve societal problems. Rosenhead had this same point of view when dealing with the area of health services planning (1978, *apud* Ackoff, 1999).

In this scenario, Ackoff (1979a) wrote an anthological paper, *The Future of Operational Research is Past*. He pointed out that the academic practice of OR abstracted from the real world and "came to be identified with the use of mathematical models and algorithms rather than the ability to formulate management problems, solve them, and implement and maintain their solutions in turbulent (messy) environments".

Strengthening the bonds: OR & Epidemiology

In this way, OR could no more aid strategic decisions of the organizations, losing its multidisciplinary skill to deal with complex problems.

Concerning the problems' approach, and in accordance to the systems thinking theory, Ackoff also considered that OR just looked after the organizations' reasons (assuming a self-control attitude, using optimization methods and objectivity values), but usually did not pay attention to its purposeful parts (lack of humanization) and/or to the larger and dynamic environmental context. In an attempt to get through these shortcomings as an applied science, a second paper was written, *Resurrecting the Future of Operational Research* (1979b), where he proposes to:

- a) Develop decision-making systems that could learn and adapt to the dynamic environment.
- b) Use of aesthetic values – stylistic preferences and ideals – that are relevant to quality of life.
- c) Look for holistic treatment to the systems of messes inside larger messes.
- d) Promote a paradigmatic change, from a preventive “predict and prepare” attitude to a creative “design a desirable future and create ways to reach it”.
- e) Reassume multidisciplinary approach.
- f) Incorporate the multitude of perspectives of all persons/ actors/ stakeholders affected by the problem.

30 years later, Kirby (2007) shows how this debate is still strongly present in the OR community. After generating a “crisis of confidence” in the discipline, it promoted the development of new insights and methodologies, mainly inside the European continent. Cited as a “Kuhnian” crisis at the 70's, according to Dando & Bennett (1981, *apud* Kirby, 2007), because the dominant framework of assumptions appeared to fail in relation to important problems, three different paradigms could be derived from it:

- a) The classical, positivist/quantitative, mechanicist, hard one, rooted on objective mathematical models or the “established methods of science”, which is a worldwide prevailing reference for OR community;
- b) The reformist/participative paradigm, advocated by Ackoff (USA) and Checkland (United Kingdom), focused on interactive planning and a social commitment, which borrowed the methodology from the social sciences and proposed the use of techniques of soft OR, placing particular emphasis on the insertion of subjectivity inside the modelling process, comprehension and structuring of the complex social problems and action-research;
- c) The revolutionary, critique or emancipatory paradigm, presented by Rosenhead & Thunhurst (1982, *apud* Kirby, 2007), which sought to guarantee that the technological and societal development OR results would be useful for all society, and not only for the dominant classes. This was the embryo of the community OR.

The awareness brought about by OR systematic thinking and modelling of a problem, focusing on the big picture; evolved into several trends for integrating social, environmental and political issues, through Structuring Methods (Rosenhead, 1989). Systems thinkers developed approaches such as system dynamics (DeTombe & Hart, 1996), soft systems methodology (SSM) (Checkland & Scholes, 1990) interactive planning (Ackoff, 1981) and critical systems heuristics (Ulrich, 1994) to deal with conflicts in complex societal problems.

Cynthia Barnhart, in charge of INFORMS presidency, aimed at “engaging OR students in using OR to address important societal problems and provide important insights that can be used to inform and shape public policy”. She launched the “Doing Good with Good OR” initiative, focusing on three daunting and immediate societal challenges: energy and environment, public health and air congestion showcased at the 2008 INFORMS Annual Meeting in Washington D.C.

Vidal (2006) discusses these paradigmatic categories, in line with Habermas theory of knowledge (Habermas, 1992). According to the German philosopher, man possesses three generic cognitive modes in which human interest generates knowledge: Technical, Practical and Emancipatory.

Technical Knowledge refers to how human beings control and manipulate world resources, assuming that there is an objective reality and that empirical-analytic sciences – like Physics, Chemistry and Biology – can make use of hypothetical-deductive theories to predict and control natural and social systems. This was the paradigm accepted by the classical OR approach.

The Practical Knowledge paradigm bases on the “communicative rationality” or “communicative action”, on human social interaction achieved by the participative encounter and on consensus of shared subjectiveness. In contrast to the first paradigm, intersubjectivity requires the understanding of meaning rather than causality, of the mutual understanding of intentions, motives and values, bounded by formal rules and guided by consensual norms. The idea of a dialogical understanding requires a more rational justification on the isolated judging subject than would a monological one. Practical knowledge is characterized, according to Habermas, by hermeneutic disciplines like, anthropology, sociology, social science, history, and legal.

Considering that both paradigms, positivist and reformist, can suffer distortions by the sociopolitical environment and power structures of society, the Critical Paradigm appears as a necessity. Moreover, the Emancipatory, critical or revolutionary paradigm focus human interest on “self-knowledge” or “self-reflection” in order to emancipate from institutional, cultural and power relationships which limit our options and rational control over our lives but have been taken for granted as beyond human control. Knowledge gained through critical self-awareness are emancipatory in the sense that at least one can recognize the correct reasons for his or her problems, leading to a transformed consciousness or ‘perspective transformation’. Examples of critical sciences include feminist theory, psychoanalysis and the critique of ideology, according to Habermas.

Nowadays, the three paradigms coexist, confronting themselves in a reflexive mode of conversation (Morgan, 1986).

3. SPECIFICITIES OF THE SCENARIO OF APPLICATION: EPIDEMIOLOGY AND HEALTH PLANNING

Health Services Planning has epidemiology as one of its most important basic sciences, which provides most of its conceptual and methodological material. Epidemiology is “the study of the distribution and determinants of health related states or events in specified populations, and the *application of this study* to control health problems” (Last, 1995).

It has also been a challenge about epidemiology’s role as an applied science, experiencing an epistemological crisis in many aspects similar to the one cited above regarding OR.

Strengthening the bonds: OR & Epidemiology

Susser & Susser (1996) described the historical evolution of modern epidemiology, with three distinct eras, as follows:

- a) Era of sanitary statistics and miasma theory to explain disease through poisoning by foul emanations from soil, air and water (first half of the 19th century);
- b) Era of infectious disease epidemiology and germ theory, as single agents relate one to one to specific diseases (late 19th century through first half of 20th century);
- c) Era of chronic disease epidemiology, with multiple causality disease explained by the “black box model”, where exposure is related to outcome without necessity for intervening factors or pathogenesis (latter half of 20th century).

In the first era, many drainage, sewage and urban sanitation actions took place, with a positive impact on population health, albeit the ignorance about the causes of diseases.

In the second era, with the theory of disease transmission by microorganisms, focus diverged from socioeconomic factors to understand the spreading of disease. Emphasis is given to the interruption of transmission chains, through vaccine developments, immunologic tests, quarantine measures and, ultimately, antibiotics.

The black box paradigm, called positivist, emerged after the Second World War, when cardiovascular disease and neoplasm overcame infectious diseases as the main causes of mortality in industrialized countries. Supported by computational and statistical techniques (mainly linear regressions), the studies related development of a chronic disease to a previous exposure to risk factors. This paradigm, also known as “risk model” or “causal inference model”, is still hegemonic, as it has many applications to the evidence based medicine practice (also known as clinical epidemiology), but it is likewise criticized as it underestimates the influence of the social context on the health-disease process (Matida & Camacho, 2004).

In the early 70's, an emancipatory or critical movement, known as Social Epidemiology, emerged to study the social determinants of disease, the excluding economic models and their impact upon life conditions. Social sciences' methods supported this current, which was quite disseminated inside Latin America (Breilh, 1991).

Another variant of criticism proposed the rescue of the epidemiology as a discipline that organizes the Public Health, with a systemic and integrative approach. This stream calls epidemiology's “transition from a science that identifies risk factors for disease to one that analyzes the systems that generate patterns of disease in populations” (Koopman, 1996). Castellanos (1995) affirms that epidemiology has, as its main goal, the description and the explanation of whole communities' health phenomena and their hierarchical interactions, for transformation. Samaja proposes that epidemiology works as open systems, and the interpretation of health events must consider three differing levels: the structure one (level of the organization), the contextual level (above, environment), and the analytical level (beneath, purposeful parts). These statements match those of the OR reformist or participative paradigm.

It is noteworthy that the legitimacy of epidemiology as a discipline has been associated with Habermas thoughts in the last decades, particularly with the practical knowledge paradigm. That is, the validity of its assumptions has assumed the form of a

communicative discourse operating between all points of view of the actors involved in the health-disease process study (Ayes, 1994).

With the rescue of the social component of epidemiology, the discipline has assumed a protagonist role in health planning by means of diagnosis of health conditions, formulation of plans, organization of health services, definition of resource allocation and assessment of systems, programs, and health policy (Teixeira, 1999). In Brazil, the 1988 Republican Constitution established the epidemiologic approach for defining priorities in health planning, with the creation of the National Unified Health System (SUS).

Health planning assumed by the government first emerged in socialist countries as an alternative regulatory mechanism to the market economy. These models have influenced the health planning in Latin America at the 60's, and were at the beginning normative, technocratic, and based on solely one actor, subordinating the shared subjectiveness to the necessity of economic development (Rivera, 2003). In this case, the main epidemiologic indicators guiding planning decisions were magnitude (based on proportional mortality), vulnerability (to treatment by current technologies) and social transcendence of diseases (age impact on population).

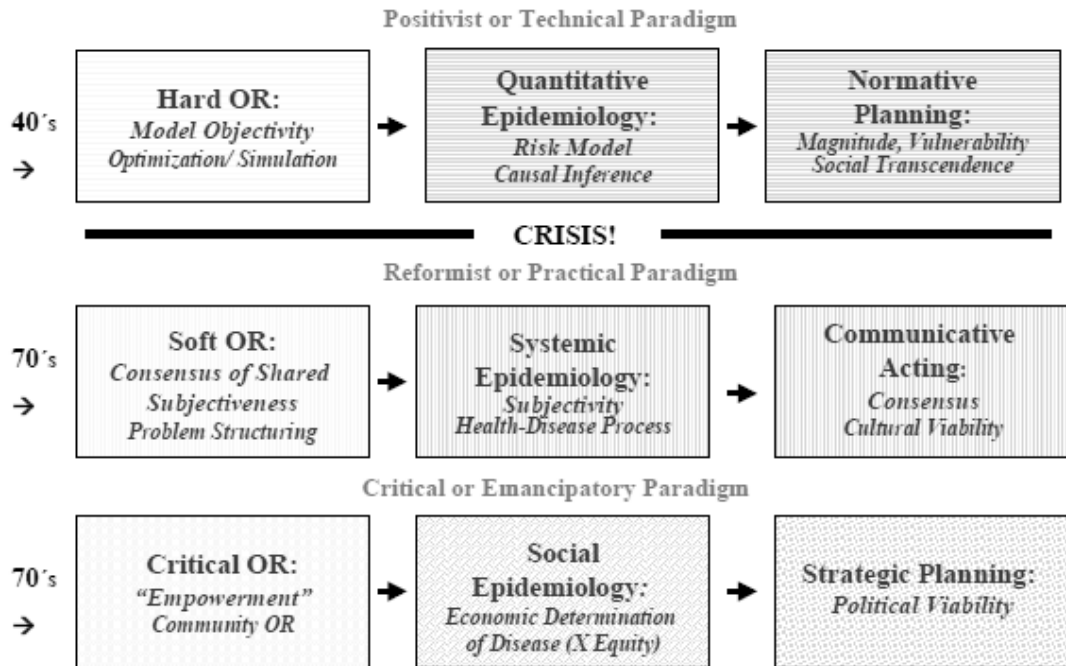
Aside from the above positivist model of health planning, there was room for the emergence of the Strategic Health Planning (SHP) in the seventies, assuming the political viability as important criteria for decision making, and calling for a participative approach in the definition of priorities (Rivera, 1989). In this case, many methodologies deriving from soft OR were incorporated to enhance the communicative flow and enable the players to reach an agreement. Techniques of Multi Criteria Decision Analysis (MCDA) also influenced the SHP practices, to construct operational matrices. SHP, thus, begun to incorporate the critical and, to a lesser extent, the reformist paradigm.

Still some criticism raised against SHP, namely: the planning technique did not consider the cultural viability of the generated proposals and it lacks methods that enhance cooperative negotiation. These latter would be emphasized in the literature of the Communicative Action planning (Rivera & Artmann, 1995). Once more, these theories and methods based on the rational cognitive theory of Habermas, aiming to generate consensus over the organization's proposals to face and solve the population's health problems in its social and historical dynamics.

4. SYNTHESIS: EPISTEMIC DIALOG BETWEEN OPERATIONAL RESEARCH AND HEALTH PLANNING & EPIDEMIOLOGY,

Management science and OR applications, and social planning share concepts and methodologies, historical experiences and paradigmatic (r) evolutions. **Figure 1** shows the correspondences amongst OR, epidemiology and health planning as presented in previous sections, as consolidated by Lobo & Lins (2010).

Figure 1: Paradigmatic correspondences between OR, Epidemiology and Health Planning (according to Habermas' Theory of Knowledge; from Lobo & Lins, 2010)



Although epidemiology precedes OR in almost a century, both disciplines have experienced a huge growth after the Second World War, supported by the development of computational tools and assumed a predominant positivist paradigm. At that time, the mathematical algorithms were sufficient to deal with strategic enterprise problems and the statistic causal inference generated important knowledge to the development of preventive and clinical medicine.

In the seventies, both disciplines experienced an epistemological crisis, associated with detachment of their methods from important social problems. From then on, based on social science methodologies, the disciplines incorporated systemic approaches and political inclusion for empowerment criteria, shaping the reformist and the critical paradigm, respectively. Note that each paradigm assumes one different component of Habermas' theory of knowledge.

Until now, there is no systematic dialogue between these two scientific areas. Instruction of operations research discipline occurs inside departments of administration or engineering, and health planning and epidemiology concepts are restricted to public health or health administration schools.

In the practical field, the early OR British reformers applied their techniques to local governments and the National Health Service (NHS). Concerning the NHS OR applications in the 70's, Smith (1995) argues that the traditional OR approach fails not because its model is an inadequate representation of reality, but because it does not acknowledge the priorities of the manager or politician in charge of the implementation. In other words, the model was mainly positivist oriented, and could be enhanced through the incorporation of new systemic and critical approaches.

In the methodological field, after the seventieth, both fields proposed a reformist perspective and placed particular emphasis on action-research for negotiation and management of change. To deal with that paradigm shift, OR analysts and health managers had a change in posture, from an advisor of top management, to a mediator of all actors trying to reach consensus (Vidal, 2006); from then on, abandoning the prescriptive and detached attitude, and thus, modifying and being modified by the modelling and planning process.

Nowadays, health services research is a multidisciplinary field of inquiry, both basic and applied, that examines the use, costs, quality, accessibility, delivery, organization, financing and outcomes of health care services. Research thus aims to increase knowledge and understanding of the structure, processes and effects of health services to individuals and populations (Aday *et al.*, 2004). To deal with the complexity of the theme, Fulop *et al.* (2001), after a workshop that joined different disciplines that usually deal with the organization and delivery of health services, published a book presenting their ongoing paradigms, uses and limitations (including epidemiology and OR).

Finally, concerning the link between health service research and health policy, we consider that the first produces knowledge about the performance of the healthcare system, and policy analysis applies this knowledge in defining problems and evaluating policy alternatives. Nonetheless, between the health research results and the policy decision making, there is judgment by the health manager. The degree to which decision makers consider the results of an evaluation varies according to their credibility, theoretical foundation and pertinence (Contandriopoulos, 2006). Policy-making processes and scientific practices themselves often appear to pose obstacles to the actual utilization of research results. According to Souza & Contandriopoulos (2004), adoption of pluralistic research systems and intensification of interfaces between researchers and policy-makers in a context of knowledge sharing would be the main strategies to improve this exchange. Such strategies, further developed as implementation science (Kroelinger *et al.*, 2014), would be efficient to the extent that they succeeded in drawing science and common sense closer together, thereby transforming both.

5. TOWARDS SYSTEMS THINKING: JOINING OR ANALYST AND HEALTH MANAGER'S PERSPECTIVES.

There is a wide consensus that health care services research and planning are complex societal problems (CSP) and that OR can provide useful tools and methodologies to deal with them. CSP and healthcare issues are multidimensional and interdisciplinary, difficult to formulate, usually have lack of data, demand multiple distinct methodologies, have great impact on society, and comprise power and emotion of the different actors involved in the problem handling process (De Tombe, 1996, 2002).

Epidemiology is a practical discipline concerned with identifying modifiable determinants of disease and cannot escape issues related to conceptualization of causality. To handle CSP characteristics, the black box paradigm that isolates the causal effects or “exposure”, holding all other factors constant, although important, may not be sufficient to support public health programs and guarantee a better community health. Identifying how the system function as a whole, acknowledging the presence of multiple levels, including biological, behavioral and environmental levels, and the existence of feedback loops and dependencies (such as individuals influencing and

affecting each other) is another essential step to deal with the complexity of the programs and interventions to put in practice (Galea et al., 2010). That is why Green (2006) advocates that public health asks for System's Science to advance the evidence-based practice to get more practice-based evidence.

One way to get practice-based evidence in real world settings is by joining methodological approaches and paradigms together. According to Mingers and Brockles by (1997), multimethodology is the "art" of use, combined, more than one methodology or part of methodologies, in order to consider, in the "best way", the various problems. Tashakkori and Teddlie (2003) call "third movement" the methodological effort to use combined methods of research, being a result of the controversies involved between two previous movements, namely the quantitative research, which dominated most of the 20th century, and the qualitative, which is characteristic of the past two decades.

While most of methods that model a problem require a specific focus on a part of the problem with the particular point of view, multimethodology considers that the focus is on the complex real world problem. A combination of methods is, thus, necessary to tackle the various natures of the problem, making use of diverse quantitative and qualitative models. This is particularly true for public policy decision aid, in educational, health, environmental and safety sectors, for instance.

Although the order of appearance of each method may depend on the problem to be treated, or the hypothesis to be tested, the structuring of matters, issues and situations is one of the stages of the modeling at the very beginning of the decision-making process (Rosenhead & Mingers, 2001). One can gather the big picture as a contextual or environmental level to elicit and organize information and structure the problem in many differing levels.

For structuring the problem, the concept or knowledge maps are graphical tools used for knowledge representation, so that a link phrase connects two concepts, generating, this way, a proposition (Okada, Buckingham and Sherborne, 2008). To construct the map, it usually considers the perspectives of multiple actors and sources, either together or in separate, as in many points of time. Each concept brought into discussion is represented by a matrix of many layers, dimensions and hierarchies interrelated by diverse types of connections, either cause-effect associations (*because; implying that*), either other positive (*through, made by*) or negative associations (*not allowed, lack of, but*). In order to integrate methodologies, the structured map shows a group of indicators and measures to use in a subsequent step, when mathematical (linear and non-linear) models are to be developed or qualitative data approached by action-research. It is noteworthy that all methods and perspectives brought back to the actors any time strengthen the internal validity of the technique. The actors' feedback and the fusion of maps often create emergence of new concepts, sometimes described as real epiphanies.

Novak (1998) presents the concept maps as a useful tool for student learning at different levels, as well as to assist in troubleshooting problems in organizations. Indeed, a graphical representation is more effective than text for the communication of complex content because the mental processing of the images can be less cognitively demanding than the verbal processing of a text (Vekiri, 2002). Guidelines on the formulation of concept maps are in Ruiz-Moreno *et al.* literature (2007).

An actual example of a concept map is presented in **Figure 2**, which shows the first step (out of 6, not shown here) in formulation and structuring of Public Health in Brazilian municipalities, using information from Public Health experts reported in legal documents as Special Checking Accounts and press interviews with government

authorities (Antoun & Lins, 2014). It is worth noting that the map gathered concepts, linking phrases and connectors that belong to four categories of phenomena, namely:

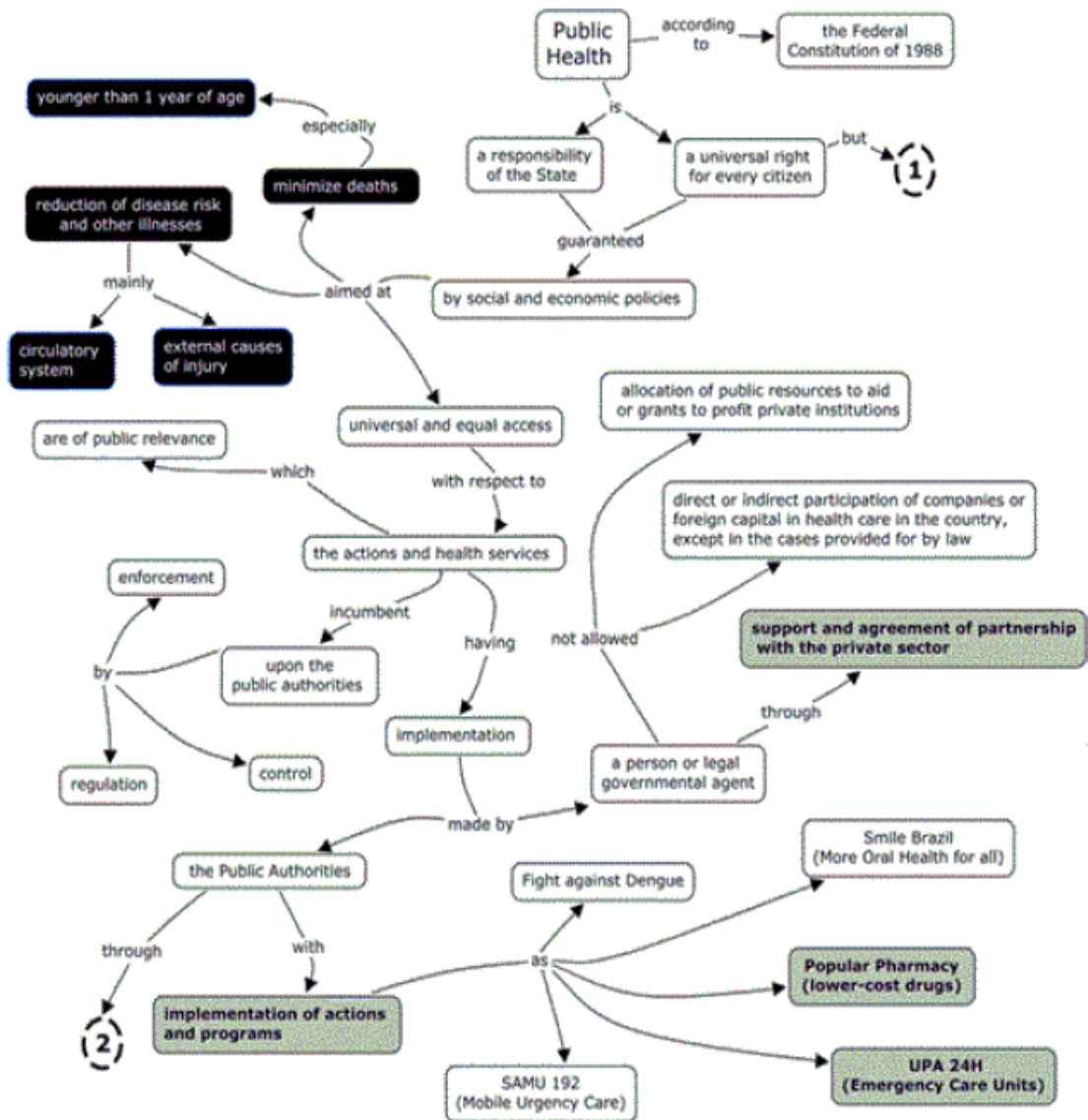
- Systemic dysfunction: characterized by high volume of diverted public money;
- Legal: represented by the legislation on healthcare in Brazil;
- Management: indicates the urgent need of professionalization of Brazilian health care management;
- Consequences: shows failure to satisfy the fundamental citizen's rights.

The above categories are interrelated in many forms, linearly, non-linearly or in loops. The political scenario gives us a legal framework where principles (*universal health care, equity*), laws (*National Unified Health System Act*), policies (*Popular Pharmacy, SAMU 192, Smile Brazil*) and rules (*management steps for programs' implementation*) are obeyed. They may also be disregarded (as in systemic dysfunction, *allocation of public grants to profit private institutions*), by public authorities, generating impacts on society that ultimately will influence the development of new policies and regulation's profiles.

In the studied case, the authors used the concepts depicted with a gray background as qualitative variables (organizational characteristics) in data mining technique to cluster types of municipalities, and the ones with a black background as quantitative variables (mortality rates) in data envelopment analysis, a management tool from hard OR to compare performance and efficiency amongst municipalities. As pointed out before, the whole map gives a context, the environmental level, where communicative consensus methods may operate. Further adopted methodologies will work with the structure and analytical levels as long as they communicate with each other. Again, the clusters of municipalities (generated by data mining) at the structural level made it possible to create homogeneous groups of municipalities to be compared at their managerial purposes and capabilities (by efficiency studies). All methods together conglomerated techniques from the positivist, reformist and critical paradigms in a form that the scientific language could be understandable to all actors that handle the analyzed problem. That is, to facilitate an interdisciplinary dialogue by interchangeable meanings and guarantee an actual problem solving process, science should be not only intelligent, but also intelligible.

In summary, much is yet to be said about the interdisciplinary debate between OR and Health Services Planning & Epidemiology. The present paper tried to show, from an epistemological dimension, how these disciplines do speak the same language, although they still do not exercise the dialog in its plenitude. They experienced similar historical turmoil and search that evolved to comparable internal solutions. The question to be answered is how to approximate their own interests, points of view and priorities in such a way that the results of one's inquiry is immediately absorbed by the decision makers without necessity of an expert mediation. One plausible and viable way is by incorporating systems thinking approaches. Multimethodology and concept maps tools, once adopted, deal with complex social problems and may consider peacefully the coexistence of different paradigms. The latter is a real board upon which actors and stakeholders exercise their communicative skills and define collaborative loops towards concepts, meanings and practical implementation.

Figure 2 –Concept Map of Brazilian Public Health (part 1). From: Antoun Neto & Lins, 2014.



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Strengthening the bonds: OR & Epidemiology

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