Systemic Intervention for Public Health

| Gerald Midgley, PhD

Many calls have been made for a systems approach to public health. My response is to offer a methodology for systemic intervention that (1) emphasizes the need to explore stakeholder values and boundaries for analysis, (2) challenges marginalization, and (3) draws upon a wide range of methods (from the systems literature and beyond) to create a flexible and responsive systems practice.

I present and discuss several well-tested methods with a view to identifying their potential for supporting systemic intervention for public health. (*Am J Public Health.* 2006;96:466–472. doi:10.2105/ AJPH.2005.067660)

BECAUSE OF THE COMPLEXITY of many public health issues, where numerous interacting variables need to be accounted for and multiple agencies and groups bring different values and concerns to bear, it is not uncommon for people to call for a systems approach.[1–5] This should not be surprising, as the whole concept of public health is founded on the insight that health and illness have causes or conditions that go beyond the biology and behavior of the individual human being. If I can give an overly simplistic definition of systems thinking as "looking at things in terms of the bigger picture" (not a definition I would want to defend in a rigorous academic fashion, but adequate for my purposes), then it should be immediately apparent that public health is already founded on a systemic insight.

Because many public health professionals are calling for a systems approach, I offer a set of methodological concepts that I have found useful in my own practice to frame systemic inquiry. Of course, many different systems methodologies have been developed over the years. There are far too many to list, let alone review (see Midgley[6] for a wider set of readings). However, the methodology I want to introduce here, which

I have called *systemic intervention* (more detailed information can be found elsewhere[7]), has the advantage of taking a pluralistic approach to the design of methods. It provides a rationale for creatively mixing methods from a variety of sources, yielding a more flexible and responsive approach than might be possible with a more limited set of tools.

I will outline this methodology before reviewing a selection of other systems approaches that have been designed for different purposes. We can borrow some useful methods from these approaches, which can then be woven into systemic intervention

practice (and more traditional scientific methods plus methods from other sources can be drawn upon in the same way). Two brief practical examples of systemic intervention illustrate my argument.

SYSTEMIC INTERVENTION

I define *intervention* as "purposeful action by an agent to create change."[7(p8)] (I accept that this definition raises questions about purpose and agency, but these are addressed in other writings.[7,8]) Note that this emphasis on intervention contrasts with the usual scientific focus on observation—although, unlike some authors who champion intervention,[9] I do not regard it as incompatible with scientific observation. Methods for observation can be harnessed into the service of intervention.[8]

Building on the above definition, I characterize *systemic* intervention as "purposeful action by an agent to create change *in relation to reflection upon boundaries*. [italics in original]"[7(p8)] One common assumption made by many systems thinkers is that everything in the universe is either directly or indirectly connected with everything else.[10–18] However, human beings cannot have a "God's-eye view" of this interconnectedness.[19] What we know about any situation has limits, and it is these limits that we call boundaries.[19,20] Comprehensive analysis is therefore impossible.[19–21] Nevertheless, by acknowledging that this is the case, and by explicitly exploring different possible boundaries for analysis, we can, paradoxically, achieve greater comprehensiveness than if we take any single boundary for granted.[7,20–22] I call this process of exploration "boundary

critique," which, for me, is the crux of what it means to be systemic.[7]

Boundary Critique

As far as I am aware, the term *boundary critique* was first coined by Ulrich[23] to refer to his own methodological practice, but here I am using it more broadly as a label for the concern with boundaries that is present in the writings of several authors, starting with Churchman.[19]

Churchman's[19] basic insight is that boundary judgments and value judgments are intimately linked. Values direct the drawing of the boundaries that determine who and what is going to be included in an intervention, so the most ethical systems practice is one that involves pushing out the boundaries as far as possible so that a wide set of stakeholder values and concerns can be accounted for (but without compromising comprehension through overinclusion).

However, Ulrich[20] argues that in practice it is often difficult to push out the boundaries in this way: time, resource, and other constraints can intrude. Ulrich therefore stresses that boundary critique should involve the justification of choices among boundaries, and should be a rational process (the widest boundary not necessarily being the most rational, given practical considerations). For Ulrich[20] (following Habermas[24]), all rational arguments are expressed in language, and language is primarily a tool for dialogue, so a boundary judgment is only truly rational if it has been agreed upon in dialogue with all those involved in and affected by an intervention. Stakeholder participation (i.e., all those involved or affected) in decisionmaking is

therefore crucial to boundary critique.

In my own research on stakeholder participation, I am interested in what happens when 2 or more groups of people make different value/boundary judgments and the situation becomes entrenched. As an aid to understanding such situations, I offer a generic model of marginalization processes that explains the persistence of conflict between stakeholders.[7] Stakeholders and issues can both be marginalized, and this marginalization can become institutionalized. The generic model and some detailed examples of marginalization have been published elsewhere.[7,25–27]

I suggest that the focus of boundary critique on stakeholder participation and marginalization makes it strongly relevant to the "new public health,"[28] which is particularly concerned with addressing disadvantage and social exclusion. For details of how boundary critique can be operationalized in health-related and other interventions, see some of the practical examples in the literature.[7,29–32]

As a brief illustration, in the late 1990s I worked with 2 colleagues (Alan Boyd and Mandy Brown) on a project to facilitate the design of new services for young people (aged less than 16 years) living on the streets.[32] We recognized (and all the relevant stakeholders concurred) that it was crucial for young people to be core participants in the research. This was a boundary judgment about participation that would have important consequences for the issues to be considered in the design process. The young people had quite specific concerns that they wanted to be addressed, and some of these would almost certainly

have been omitted if participation had been limited to professionals alone.

However, when involving young people, we had to be aware that there was a double danger of marginalization: in general, young people under 16 years of age are viewed as less "rational" than adults. Also, these particular young people could easily have been stereotyped as troubled and untrustworthy teenagers (because, in order to survive on the streets, many of them had to resort to begging, petty crime, or prostitution). Therefore, in setting up design workshops, we gave the young people space out of the hearing of professionals to develop their ideas (an empowerment technique) and we used exactly the same planning methods as we used with the adult participants to generate proposals for change. This allowed a direct comparison to be made between the ideas from the young people and adults, and prevented the kind of marginalization that might have occurred if we had used a more "playful" approach with the young people and a more traditional "rational planning" method with the professionals. It would have been easy, if we had done the latter, for the professionals to have viewed only their own output as the "proper" plan. This was just 1 of many issues that we explored and addressed through our boundary critique.

Methodological Pluralism

In addition to boundary critique, I also advocate 2 forms of methodological pluralism. The first is learning from other methodologies to inform one's own. This way, each agent has a continually developing systems

methodology. We no longer have to accept a situation where people build a methodology like a castle and then defend it against others who want to breach the castle walls. Rather, if people begin to see methodology as dynamic and evolving, they can learn from others on an ongoing basis.[7]

The second form of methodological pluralism is about drawing upon and mixing methods from other methodologies. The wider the range of methods available, the more flexible and responsive our systems practice can be.[7,33–43] No methodology or method (whether it comes from the systems tradition or elsewhere) can do absolutely everything people might want. Therefore, being able to draw upon multiple methods from different paradigmatic sources can enhance the systems thinking resource we have available for intervention. See Luckett and Grossenbacher[44] and Boyd et al.[32] for some practical examples of methodological pluralism in systemic public health planning.

As a brief illustration, the aforementioned project to facilitate the design of new services for young people living on the streets used a number of different interlinked methods and techniques:

- Individual interviews with young people, foster caretakers, and retailers;
- The use of photographs and cards with evocative pictures to stimulate ideas;
- A focus group with staff working in a children's home;
- Rich pictures (visual depictions of the problem situation using drawings and arrows showing the links between key issues—see the "Soft Systems Methodology" section of this article for the origins of this technique);

- A synergy of 2 systemic planning methods (see the "Interactive Planning" and "Critical Systems Heuristics" sections of this article for details) implemented in separate stakeholder and multiagency workshops;
- Values mapping (a method we developed to visualize people's values and the logical connections between them);
- Small group, multiagency action planning;
- The production of reports, magazines, and posters for multi-audience dissemination; and
- Formative evaluation (feedback questionnaires filled in by participants).

In the view of the research team,[32] no existing methodology was able to provide all the methods needed for this project. Methodological pluralism was absolutely necessary.

Added Value

Arguably, the main added value of systemic intervention compared with earlier systems approaches is its synergy of boundary critique and methodological pluralism.[32] If boundary critique is practiced on its own, it is possible to generate some interesting sociological analyses, but there is a danger that these will not effect change unless other more action-oriented methods are used too.[37] Also, embracing methodological pluralism without up-front boundary critique can give rise to superficial diagnoses of problematic situations. If a complex issue is defined from only 1 limited perspective without reflecting on values and boundaries, and issues of marginalization are neglected, then the outcome could be the use of a systems approach that misses or even exacerbates significant

social problems.[7,45] The synergy of boundary critique and methodological pluralism ensures that each aspect of systemic intervention corrects the potential weaknesses of the other.[7,32]

OTHER RESOURCES FOR SYSTEMS THINKING

Arguably, one of the great strengths of the systems movement is the variety of methods that have been developed to serve different purposes over the years.[6] If we can begin to harness this variety into a form of systems practice that still keeps the idea of reflecting on value and boundary judgments at its core, I believe we will have a great deal to offer public health in the coming years. Below I provide some examples of other systems approaches, which have methods that can be incorporated into systemic intervention. These have been widely applied in practice and offer tools that I have found useful in my own public health research.

System Dynamics

System dynamics[46–51] offers methods for modeling complex feedback processes and considering possible impacts of changes to the system of concern. By experimenting with a model, decisionmakers are able to anticipate possible emerging scenarios that could follow from a new policy initiative or intervention.

System dynamics has been used to address a number of significant public health issues.[52,53] It gives public health professionals some useful tools to model feedback processes in a manner that can not only help to make transparent why certain health effects might occur at the population level, but can also

help policymakers anticipate counterintuitive effects of public health initiatives. As Forrester[54] has demonstrated, some policies, introduced with the best of intentions, have the opposite effects of those that are desired. By modeling the feedback loops that stabilize and/or destabilize the system of concern, the approach can highlight surprising side effects of policy options that might not otherwise have been visible in advance of implementation.

The Viable System Model

The second methodology of interest is the viable system model,[55–60] which proposes that for an organization to become and remain viable in a complex and rapidly changing environment, it must carry out each of the following 5 functions:

- Operations: the provision of products or services that address particular needs in the organization's environment;
- Coordination: ensuring that the operational units work together and communicate effectively;
- Support and control: especially with regard to distributing resources, providing training, gathering and distributing information about quality, etc.;
- Intelligence: the forecasting of future needs, opportunities, and threats. This involves a comparison between the external requirements placed upon the organization and its internal capacity; and
- Policymaking: setting long-term goals and objectives.

According to the viable system model, the key to effective organization is not only to make sure that all 5 functions exist, but also to ensure that communications among the functions are appropriate and effective. Together,

these functions manage the information and decision flows necessary for effective organization, and consequently each function is of equal importance. The model can be used to diagnose current organizational failings or to design entirely new organizations.

Given the complexities of public health policymaking and service delivery, organizational viability is an important factor. For professionals to be able to respond adequately to the issues they face, they need to have an effective organizational infrastructure behind them. The viable system model could make a useful contribution to organizational development.

Interactive Planning

Although system dynamics and the viable system model involve modeling ecological, social, and/or organizational systems, other methodologists have moved away from modeling to focus on the facilitation of dialogue among stakeholders who bring different insights to bear on complex issues. An example is Ackoff,[61–63] whose methodology of interactive planning seeks to liberate and harness the knowledge and creative abilities of everybody in (and often including stakeholders beyond) an organization to produce a plan of the ideal future that the organization can work toward. The plan may take some time to implement, perhaps many years, but it offers a feasible set of targets for the longer term. A key idea is that the plan should be wide enough and creative enough to "dissolve" any disagreements among participants. The transformation it proposes should result in the commitment of all concerned.

The approach can be represented in the form of 3 stages:

(1) establishing planning boards (every role in the organization should be represented in planning, with participation as widespread as possible); (2) generating desired properties of the organization's products and/or activities (this is "ends planning," conducted under conditions of minimum constraint with only technological feasibility, viability, and adaptability limiting proposals); and (3) producing the plan itself ("means planning," where all sections of the organization agree on how to move forward).

I have used aspects of Ackoff's work in my own public health research, for example, to look at how the mental health and criminal justice systems would have to be changed to prevent people with mental health problems from inappropriately ending up in prison.[7,64] If organizations are willing to commit the resources to participative planning, I believe this is a useful approach that can help people move beyond everyday fire fighting toward the formulation of inspiring (but still feasible) long-term visions of how public health can be improved. My only caveat is that in the area of public health it will usually be important to extend participation beyond the boundaries of a single organization to take in other agency representatives and community groups. I have always used interactive planning in this wider participative manner, and it puts some responsibility on the systems practitioner to ensure that marginalized groups are properly included.[7]

Soft Systems Methodology

Another approach that can be used to facilitate dialogue among stakeholders is soft systems methodology.[65,66] This encourages

participants in intervention to generate issues through ongoing explorations of their perceptions, allowing people to model desirable future human activities. These models of future human activities can then be used as a basis for guiding actual human activities in the world. However, to ensure that the models will indeed be useful, it is necessary for participants to relate them back to their perceptions of their current situation. In this way, possibilities for change can be tested for feasibility.

The methods of soft systems methodology, which are often operationalized in a workshop format, can be summarized as follows: (1) Consider the problem situation in an unstructured form; (2) Produce a "rich picture" (a visual representation—with pictures and arrows to represent links between issues—of the current situation); (3) Identify possible "relevant systems" that might be designed to improve the situation, and harmonize understandings of these by exploring who should be the beneficiaries of a proposed system change, who should carry it out, what the transformation should be, what worldview is being assumed, who could prevent the change from happening, and what environmental constraints need to be accepted; (4) Produce a "conceptual model" for each relevant system (a map of the interconnected human activities that need to be undertaken if the system is to become operational); (5) Refer back to the rich picture to check the feasibility of the ideas; (6) Produce an action plan; and (7) Proceed to implementation. Of course, participants need to move backward and forward among these activities, harmonizing the outputs

from each one with the others—the activities should not be implemented mechanistically in a linear sequence.

Soft systems methodology has been used in several public health and health management interventions.[67,68] It provides a useful language to ensure that ongoing planning retains a systemic focus, and can support people in making accommodations to find acceptable ways forward when they have different perspectives on an issue. I have found it particularly useful for multiagency planning—for example, when facilitating a debate among 19 agency representatives who wanted to cooperate on the design of a counseling service that could be activated in the event of a major disaster, but their different perspectives were obstructing progress. Over 6 days, the agencies came to an agreement that resulted in the design, funding, and implementation of the counseling service.[7,69]

Critical Systems Heuristics

The final methodology I want to review is Ulrich's critical systems heuristics.[20,70] As mentioned previously (in the section on "Boundary Critique"), Ulrich asks, when people make decisions on who to consult and what issues to include in planning, how can people rationally justify the boundaries they use?[20] An important aspect of Ulrich's thinking about boundaries is that boundary and value judgments are intimately linked[20]: the values adopted will direct the drawing of boundaries that define the knowledge accepted as pertinent. Similarly, the inevitable process of drawing boundaries constrains the values that can be pursued. Being

concerned with values, boundary critique is an ethical process. Because of the focus on dialogue among stakeholders in dealing with ethical issues, a priority for Ulrich is to evolve practical guidelines that planners and ordinary citizens can both use equally proficiently to conduct boundary critique.[20] For this purpose, he offers a list of 12 questions that can be employed by those involved in and affected by planning to interrogate what the system currently is, and what it ought to be. These 12 questions cover 4 key areas of concern: motivation, control, expertise, and legitimacy.

In my view, there is significant potential for using Ulrich's 12 questions in public health planning, not least because they cut to the heart of many issues that are of fundamental concern to people in communities who find themselves on the receiving end of policies and initiatives that they either do not agree with or find irrelevant. In my own research, I have used these questions with people with mental health problems recently released from prison,[7,64] older people in sheltered housing,[7,29,71] young people who have run away from children's homes,[7,32,72] and others. Ulrich claims that his questions can be answered equally proficiently by "ordinary" people with no experience of planning as they can by professionals,[20] and my experience tells me that he is right—with the caveat that the questions should be made specific to the plans being discussed, and also need to be expressed in plain English. If the questions about what ought to be done are asked early on in planning a new public health initiative, I have found that

"ordinary" people are usually able to think just as systemically as professionals (indeed, sometimes more so).[7]

A PRACTICAL EXAMPLE

To further ground this presentation of methodology, I briefly outline another systemic intervention that I undertook, again with 2 colleagues (Isaac Munlo and Mandy Brown). Only a sketch of this intervention is provided, and therefore many of the social dynamics that were important to it have been omitted. However, more detailed expositions can be found elsewhere.[7,29,71,73]

The initial remit of the project, funded by the Joseph Rowntree Foundation, was to work with local governments in the United Kingdom to find out how information from assessments of older people applying for health, housing, and welfare services could be aggregated to inform the development of housing policy. However, some initial interviews with stakeholders quickly revealed that there were 2 major problems with the boundaries of our study.

First, it became apparent that if the housing "needs" expressed by older people fell outside local government spending priorities, they were not recorded. This meant that aggregating information from assessments would paint an artificially rosy picture, making it seem as if all needs were being met. Second, many urgent problems with service provision, assessment, and multiagency planning were being raised by stakeholders (including older people themselves). We felt that ignoring these would be unethical—especially as we had already come to the conclusion that the initial remit of the intervention was flawed. As a

consequence, we worked with the funder to expand the remit of our study to look at the wider system of assessment, information provision, and multiagency planning for older people's housing, and what could be done to improve it.

Semistructured interviews with 131 stakeholders from a wide variety of organizations (including older people themselves) yielded data that we used to create a "problem map." This is similar to a system dynamics model, except that problem mapping is purely qualitative. The purpose is to demonstrate to stakeholders that their problems are strongly interdependent and, therefore, to be resolved, they require changes to the wider system.

Having demonstrated the systemic nature of the issues, the next stage was to ask what kind of system change was needed. To answer this, we held a series of interactive planning workshops, asking what ideal (but still technologically feasible, viable, and adaptable) housing services would look like. We integrated the critical systems heuristics questions so we could explore issues of motivation (or purpose), control (including governance), expertise, and legitimacy. To prevent the marginalization of older people, we worked with them separately from professionals, allowing them more time and space to develop their views. The interactive planning/critical systems heuristics workshops demonstrated a widespread agreement among stakeholders on housing policy, with only a few relatively minor disagreements needing resolution.

We then brought together senior managers from health, housing, and welfare organizations to look at what kind of organizational system could deliver the

housing services that the stakeholders had asked for. We introduced the viable system model as a template for the organizational design, and systematically evaluated this design using criteria derived from the earlier work with older people and frontline professionals (thereby ensuring that these perspectives were not marginalized now that participation had been narrowed to managers). In this way, we could be reasonably confident that the managers' proposals would either meet the stakeholders' requirements directly or would provide the organizational means to address them in future years.

This example of systemic intervention demonstrates the benefits of boundary critique: The initial problematic remit of the project was usefully expanded, and the potential for marginalizing older people was identified and addressed. It also demonstrates the value of methodological pluralism. In my view, no single set of methods yet developed could have addressed all the issues in this intervention. It took a combination of semistructured interviewing, problem mapping, interactive planning, critical systems heuristics, and viable system modeling to support stakeholders in both defining the issue and responding to it systemically.

CONCLUSION

I have presented a methodology for systemic intervention (incorporating boundary critique and methodological pluralism), and have discussed several systems approaches from which we can borrow useful methods. I have also provided 2 practical examples of systemic intervention.

I suggest that this kind of approach is not only able to address issues of values, boundaries, and marginalization in defining complex problems (making it particularly relevant to the "new public health"[28]), but it also has the potential to deliver all the utility of other systems approaches because it explicitly advocates learning about and drawing methods from those approaches to deliver maximum flexibility and responsiveness in systemic interventions.

In my view, systems thinking has the potential to make a significant difference to public health, so (if you have not already done so) I invite you to try out some of the ideas and methods touched upon in this article, and share your experiences with others so that the whole public health research community can be enriched in the process. ∎

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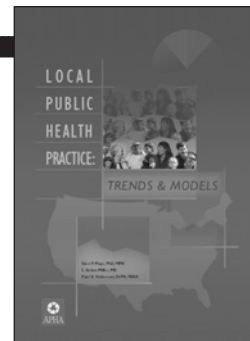
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References

1. Laporte RE, Barinas E, Chang Y-F, Libman I. Global epidemiology and public health in the 21st Century: Applications of new technology. *Ann Epidemiol.* 1996;6:162–167.

2. Holder HD. Prevention of alcohol problems in the 21st century: challenges and opportunities. *Am J Addict.* 2001:10;1–15.

3. Best A, Moor G, Holmes B, et al. Health promotion dissemination and systems thinking: Towards an integrative model. *Am J Health Behav.* 2003;27 (suppl 3):S206–S216.

4. Best A, Stokols D, Green LW, Leischow S, Holmes B, Buchholz K. An integrative framework for community partnering to translate theory into effective health promotion strategy. *Am J Health Promot.* 2003;18: 168–176.

5. World Health Organization and World Bank. *World Report on Road Traffic Injury Prevention.* Geneva, Switzerland: World Health Organization; 2004.

6. Midgley G. *Systems Thinking.* Volumes I–IV. London, England: Sage Publications; 2003.

7. Midgley G. *Systemic Intervention: Philosophy, Methodology, and Practice.* New York, NY: Kluwer Academic/ Plenum Publishers; 2000.

8. Midgley G. Science as systemic intervention: Some implications of systems thinking and complexity for the philosophy of science. *Syst Pract Act Res.* 2003;16:77–97.

9. Seidman E. Back to the future, community psychology: Unfolding a theory of social intervention. *Am J Community Psychol.* 1988;16:3–24.

10. Bogdanov AA. *Bogdanov's Tektology.* Dudley P, ed. Hull, England: Centre for Systems Studies Press; 1996 [first published in Russian 1913–1917].

11. Koehler W. *The Place of Values in the World of Fact.* New York, NY: Liveright; 1938.

12. Boulding KE. General systems theory—the skeleton of science. *Manage Sci.* 1956;2:197–208.

13. Kremyanskiy VI. Certain peculiarities of organisms as a "system" from the point of view of physics, cybernetics and biology. *General Systems.* 1958;5: 221–230.

14. Von Bertalanffy L. *General Systems Theory.* London, England: Penguin; 1968.

15. Bateson G. *Steps to an Ecology of Mind.* Northvale, NJ: Jason Aronson Publishers; 1972.

16. Miller JG. *Living Systems.* New York, NY: McGraw-Hill; 1978.

17. Prigogine I, Stengers I. *Order out of Chaos: Man's New Dialogue with Nature.* London, England: Fontana; 1984.

18. Laszlo E. *The Interconnected Universe: Conceptual Foundations of Transdisciplinary Unified Theory.* London, England: World Scientific Publishing, 1995.

19. Churchman CW. Operations research as a profession. *Manage Sci.* 1970;17:B37–B53.

20. Ulrich W. *Critical Heuristics of Social Planning: A New Approach to Practical Philosophy.* Bern, Switzerland: Verlag Paul Haupt; 1983.

21. Cilliers P. *Complexity and Postmodernism: Understanding Complex Systems.* London, England: Routledge; 1998.

22. Midgley G, Ochoa-Arias AE. An introduction to community operational research. In: Midgley G, Ochoa-Arias AE, eds. *Community Operational Research: OR and Systems Thinking for Community Development.* New York, NY: Kluwer Academic/Plenum Publishers; 2004.

23. Ulrich W. *Critical Systems Thinking for Citizens: A Research Proposal.* Centre for Systems Studies Research Memorandum #10. Hull, England: Centre for Systems Studies, University of Hull; 1996.

24. Habermas J. *Communication and the Evolution of Society.* English ed., 1979. London, England: Heinemann; 1976.

25. Midgley G. The sacred and profane in critical systems thinking. *Syst Pract.* 1992;5:5–16.

26. Midgley G. Ecology and the poverty of humanism: A critical systems perspective. *Syst Res.* 1994;11:67–76.

27. Yolles M. Viable boundary critique. *J Operat Res Soc.* 2001;52: 35–37.

28. Baum F. *The New Public Health: An Australian Perspective.* Melbourne, Australia: Oxford University Press; 1998.

29. Midgley G, Munlo I, Brown M. The theory and practice of boundary critique: Developing housing services for older people. *J Operat Res Soc.* 1998; 49:467–478.

30. Córdoba J, Midgley G. Addressing organisational and societal concerns: An application of critical systems thinking to information systems planning in Colombia. In: Cano J, ed. *Critical Reflections on Information Systems: A Systemic Approach.* Hershey, Pa: Idea Group Publishing; 2003.

31. Baker V, Foote J, Gregor J, Houston D, Midgley G. Boundary critique and community involvement in watershed management. In: Dew K, Fitzgerald R, eds. *Challenging Science: Issues for New Zealand Society in the 21st Century.* Palmerston North, New Zealand: Dunmore Press; 2004.

32. Boyd A, Brown M, Midgley G. Systemic intervention for community OR: Developing services with young people (under 16) living on the streets. In: Midgley G, Ochoa-Arias AE, eds. *Community Operational Research: OR and Systems Thinking for Community Development.* New York, NY: Kluwer Academic/Plenum Publishers; 2004.

33. Jackson MC, Keys P. Towards a system of systems methodologies. *J Operat Res Soc.* 1984;35:473–486.

34. Flood RL. *Liberating Systems Theory.* New York, NY: Plenum Press; 1990.

35. Jackson MC. *Systems Methodology for the Management Sciences.* New York, NY: Plenum Press; 1991.

36. Flood RL, Jackson MC, eds. *Critical Systems Thinking: Directed Readings.* Chichester, England: John Wiley and Sons; 1991.

37. Flood RL, Jackson MC. *Creative Problem Solving: Total Systems Intervention.* Chichester, England: John Wiley and Sons; 1991.

38. Midgley G. Pluralism and the legitimation of systems science. *Syst Pract.* 1992;5:147–172.

39. Flood RL, Romm NRA, eds. *Critical Systems Thinking: Current Research and Practice.* New York, NY: Plenum Press; 1996.

40. Gregory WJ. Discordant pluralism: A new strategy for critical systems thinking? *Syst Pract.* 1996;9:605–625.

41. Mingers J, Gill A, eds. *Multimethodology: The Theory and Practice of Combining Management Science Methodologies.* Chichester, England: John Wiley and Sons; 1997.

42. Jackson MC. *Systems Approaches to Management.* New York, NY: Kluwer Academic/Plenum Publishers; 2000.

43. Jackson MC. *Systems Thinking: Creative Holism for Managers.* Chichester, England: John Wiley and Sons; 2003.

44. Luckett S, Grossenbacher K. A critical systems intervention to improve the implementation of a district health system in KwaZulu Natal. *Syst Res Behav Sci.* 2003;20:147–162.

45. Ulrich W. Some difficulties of ecological thinking, considered from a critical systems perspective: A plea for critical systems holism. *Syst Pract.* 1993;6: 583–611.

46. Forrester JW. *Industrial Dynamics.* Cambridge Mass: MIT Press; 1961.

47. Sterman JD. Learning in and about complex systems. *Syst Dyn Rev.* 1994; 10:291–330.

48. Morecroft JDW, Sterman JD, eds. *Modeling for Learning Organizations.* Portland, Ore: Productivity Press: 1994.

49. Vennix JAM. *Group Model Building: Facilitating Team Learning Using System Dynamics.* Chichester, England: John Wiley and Sons; 1996.

50. Coyle RG. *System Dynamics Modelling: A Practical Approach.* London, England: Chapman and Hall; 1996.

51. Maani KE, Cavana RY. *Systems Thinking and Modelling: Understanding Change and Complexity.* Auckland, New Zealand: Prentice Hall; 2000.

52. Sudhir V, Srinivasan G, Muraleedharan VR. Planning for sustainable solid waste management in urban India. *Syst Dyn Rev.* 1997;13:223–246.

53. Townshend JRP, Turner HS. Analysing the effectiveness of *Chlamydia* screening. *J Operat Res Soc.* 2000;51:812–824.

54. Forrester JW. Counterintuitive behavior of social systems. *Theory and Decision.* 1971;2:109–140.

55. Beer S. *Cybernetics and Management.* Oxford, England: English Universities Press; 1959.

56. Beer S. *Decision and Control.* Chichester, England: John Wiley and Sons; 1966.

57. Beer S. *Brain of the Firm.* 2nd ed. Chichester, England: John Wiley and Sons; 1981.

58. Beer S. The viable system model: Its provenance, development, methodology and pathology. *J Operat Res Soc.* 1984;35:7–25.

59. Beer S. *Diagnosing the System for Organisations.* Chichester, England: John Wiley and Sons; 1985.

60. Espejo R, Harnden RJ, eds. *The Viable System Model: Interpretations and Applications of Stafford Beer's VSM.* Chichester, England: John Wiley and Sons; 1989.

61. Ackoff RL. *Redesigning the Future: A Systems Approach to Societal Problems.* Chichester, England: John Wiley and Sons; 1974.

62. Ackoff RL. Resurrecting the future of operational research. *J Operat Res Soc.* 1979;30:189–199.

63. Ackoff RL. *Creating the Corporate Future.* New York, NY: John Wiley and Sons; 1981.

64. Cohen C, Midgley G. *The North Humberside Diversion From Custody Project for Mentally Disordered Offenders: Research Report.* Hull, England: Centre for Systems Studies; 1994.

65. Checkland P. *Systems Thinking, Systems Practice.* Chichester, England: John Wiley and Sons; 1981.

66. Checkland P, Scholes J. *Soft Systems Methodology in Action.* Chichester, England: John Wiley and Sons; 1990.

67. Checkland P. Rhetoric and reality in contracting: Research in and on the NHS. In: Flynn R, Williams G, eds. *Contracting for Health.* Oxford, England: Oxford University Press; 1997.

68. Fahey DK, Carson ER, Cramp DG, Muir Gray JA. Applying systems modelling to public health. *Syst Res Behav Sci.* 2004;21:635–649.

69. Gregory WJ, Midgley G. Planning for disaster: Developing a multiagency counselling service. *J Operat Res Soc.* 2000;51:278–290.

70. Ulrich W. Critical heuristics of social systems design. *Eur J Operat Res.* 1987;31:276–283.

71. Midgley G, Munlo I, Brown M. *Sharing Power: Integrating User Involvement and Multi-Agency Working to Improve Housing for Older People.* Bristol, England: Policy Press; 1997.

72. Boyd A, Brown M, Midgley G. *Home and Away: Developing Services with Young People Missing from Home or Care.* Hull, England: Centre for Systems Studies; 1999.

73. Midgley G. Ethical dilemmas: A reply to Richard Ormerod. *J Operat Res Soc.* 1999;50:549–553.