Social Factors in Creating an Integrated Capability for Health System Modeling and Simulation

Paul P. Maglio, Melissa Cefkin, Peter J. Haas, and Pat Selinger

IBM Research – Almaden, San Jose, California
{pmaglio,mcefkin,peterh,patseli}@us.ibm.com

Abstract. The health system is a complex system of systems – changes in agriculture, transportation, economics, family life, medical practices, and many other things can have a profound influence on health and health costs. Yet today, policy-level investment decisions are frequently made by modeling individual systems in isolation. We describe two sets of issues that we face in trying to develop a platform, method, and service for integrating expert models from different domains to support health policy and investment decisions. The first set of questions concerns how to develop accurate social and behavioral health models and integrate them with engineering models of transportation, clinic operations, and so forth. The second set of questions concerns the design of an environment that will encourage and facilitate collaboration between the health modelers themselves, who come from a wide variety of disciplines.

Keywords: Health, Policy, Models, Simulation, Social Factors.

1 Toward a Science of Health Policy Decision Making

The health system of any nation is a complex system of systems. Decisions about comparative effectiveness or about investment in prevention or treatment programs may lead to complex interactions and have widespread consequences, many of which may be difficult to foresee. For example, the treatment of chronic diseases presents multi-faceted issues that the healthcare sector alone cannot address. Transportation, agriculture, housing, and education "have far-reaching health effects, but are not engaged or evaluated for those outcomes" [4]. Indeed, it is generally recognized that chronic diseases such as obesity reflect cultural, social, educational, political, and economic conditions as well as policies, practices, costs, and pricing in industries such as advertising, transportation, agriculture and others [8]. Certain sorts of behavioral modeling approaches may be appropriate for simulating some aspects of chronic disease [1,6], and various kinds of system modeling may be useful for simulating complex interactions of the effects of policies [7,13]. But a full understanding of such a complex system of systems – like the health system – can be enabled by modeling all relevant aspects of each constituent real-world system, probably by different experts using different modeling techniques, and then integrating the resulting models to "try out" alternatives. Though there have been some efforts at building frameworks that encompass data of various sorts to model and predict policy-level outcomes

S.-K. Chai, J.J. Salerno, and P.L. Mabry (Eds.): SBP 2010, LNCS 6007, pp. 44–51, 2010.

(e.g., [16]), there exists no overarching platform or framework with which to integrate disparate models based on distinct technologies and deep domain expertise.

To address this unmet need, we are developing a platform, method, and service to support such an integration of models. The *Smarter Planet Platform for Analysis and Simulation of Healthcare* – also known as *Splash!* – aims to enable the integration of independently created, deep models of health-related domains in an environment that is practical, flexible, cost-effective, and usable. Our goal is to have an impact on health at policy and investment levels, in understanding comparative effectiveness of treatments and preventions, in determining return on investment at an ecosystem level, and in understanding global consequences of decisions. Numerous technical and conceptual challenges must be addressed to integrate diverse models.

In this paper, we summarize some of the research challenges brought to the fore when considering social factors related to health and health policy, and the formation of an integrated modeling capability. We identify a dual set of challenges: (1) What particular issues must be faced in integrating social and behavioral models with statistical and deterministic models derived from other conceptual domains and data sources? And (2) how might the social conditions of different modelers and communities of experts themselves – their varying disciplinary assumptions, practices, and concerns – be addressed so that Splash! effectively enables collaboration that supports development of practical and meaningful results? We believe that the core research questions identified and raised in this examination represent important initial steps toward identifying opportunities to advance contributions of social and behavioral modeling to health and health policy. We also aim ultimately to provide insight on how joint efforts between modeling and policy communities – and multiple disciplines more generally – can continue to interact productively, forging innovative advances to knowledge and action.

2 The Splash! Approach: Architecture and Challenges

Currently, there are no means for usefully combining multiple independently created models to inform the kind of complex decision making demanded of health policy. There are many reasons why diverse models are rarely combined to create a comprehensive, detailed picture of any real system of systems. Different categories of models are constructed, maintained, and used by different people and organizations, each using distinct terms, conventions, and approaches. The challenges to creating integrated views are both technical and social, emerging in part from varied intellectual and scientific histories and practices.

2.1 Overall Architecture and Challenges for Model Integration

There are four main challenges to composing large-scale models for complex health ecosystems. First, *not all models can be combined in a sensible way*. The assumptions, time scales, capabilities, level of detail, and indeed the selection of the key aspects to represent may be quite different: What factors characterize the models that are compatible with one another? The challenge is to develop a deep understanding of model compatibility.

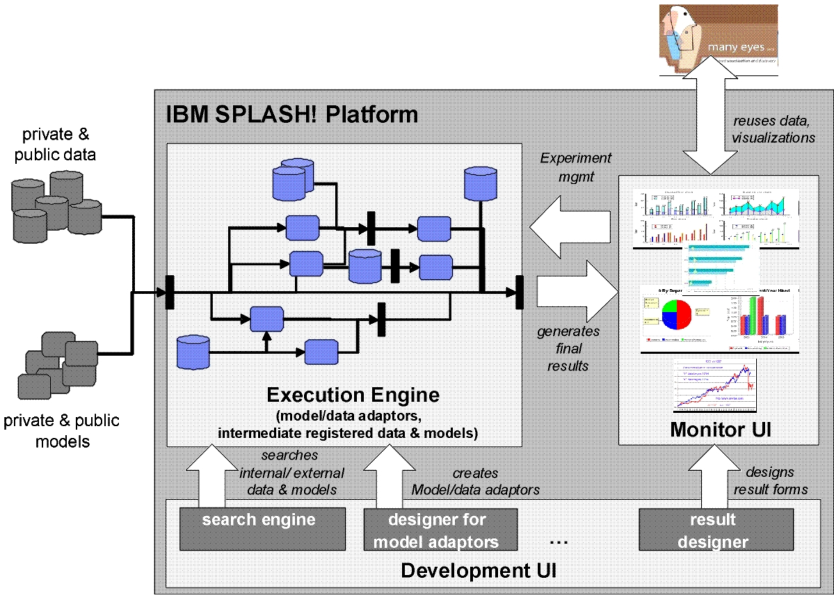

Fig. 1. Splash! will be an open community platform where proprietary and public models, data, and outcomes can be searched, combined, executed, visualized, and shared

Second, *there exists no standard way to describe models in sufficient depth to determine compatibility*. Here, the challenge is to create mechanisms and methods for describing models so that it is easy to determine how to integrate them into larger, more complex models of larger, more complex systems.

Third, *there are no tools or platforms to support the integration of independently created models in a simple, flexible, and useful way*. This adds the challenge of providing efficient mechanisms for searching and identifying applicable models, for establishing an appropriate execution environment, for automatically generating connectors between models and datasets, and for enabling reuse, result pruning, data transformations, flexible model transformations, experiment management, visualization, simulation output analysis, and so on (see Figure 1).

Fourth, *there is no targeted technology and set of practices to facilitate collaboration between the varied people and organizations that develop and use distinct domain models.* We envision an active community of participants contributing models and data, combining models, discussing models, exploiting previous results, and optionally sharing their models and modeling results. Participants in such an open community must have the means to (a) combine their proprietary models and data securely without risking intellectual property or violating privacy, (b) evaluate the quality of models and transformations used and communicate their findings to others, and (c) assess the trustworthiness of the outcomes produced. The final challenge is to develop a deep understanding of what is required for such an open integrated community system to successfully enable cooperation among all stakeholders.

Here, we ask whether and in what ways the inclusion of social computing approaches and social models into the integrated mix of models envisioned in Splash! presents particular challenges. What assumptions, forms of modeling, and language use, for instance, inform social and behavioral modeling in the health domain? We think that for the technology and supporting practices for Splash! to be useful, usable, and effective, they must be grounded in an understanding of the work and collaboration practices of the varied people and organizations that develop and use these models. So the fourth challenge identified above follows from the first three in that it is underlined by basic questions of the compatibility of the assumptions informing the models as well as the ways of describing them. These assumptions and languages, in turn, are informed by the varying social and intellectual histories of different scientific disciplines and other communities of experts. Historians of science and social scientists in the area of science and technology studies offer insight for consideration of what happens when different scientific and policy communities come together, suggesting ways that differences both challenge and create opportunities for greater advancement.

2.2 Challenges for Social and Behavioral Modeling

Consider the case of chronic disease management, such as obesity. Not only do numerous social factors inform underlying health conditions, but the interplay of social factors in determining impact of various forms of intervention is undeniable [9]. The number of factors affecting health outcomes is multilayered and highly complex (see Figure 2).

For instance, recent studies have examined how environmental factors contributing to access to food, as determined by availability and price, correlate with variable health outcomes. Findings have shown that lower food prices are associated with consumption of those food products; for instance, lower priced fruits and vegetables are associated with greater consumption of these products while lower priced fast food is associated with lower fruit and vegetable consumption. The ability to benefit from lower prices depends on the potential access to them to begin with, hence the shortage of markets selling lower priced fruits and vegetables in lower income areas is seen to contribute to higher rates of obesity in such communities [3]. Various policy interventions are possible, such as providing tax benefits to merchants for supplying lower-cost healthy food. What is needed is the ability to simulate the potential impact of such a move given the dynamic and non-deterministic dimensions of the social factors contributing to impact. In addition to being dynamic, finding appropriate means of defining the parameters of social factors introduces additional challenges. For instance, changing forms of ethnic identification and residence patterns (e.g., Pacific Islanders and traditionally African-American areas) and attendant shifts in consumer behavior must be considered.

Indeed social networks have been shown to reveal interesting patterns of obesity and weight gain and loss. Building off the data available through the longitudinal Framingham Heart Study, analysis of social networks conducted by Bahr et al. [1] identifies obesity clusters to be more prevalent at the second and third degrees of relationship – friends and friends of friends – rather than in familial or spousal units. They simulate the effect of certain social forces, such as advertising or taxation, on particular spots in the networks as predictive exercises in guiding potential policy.

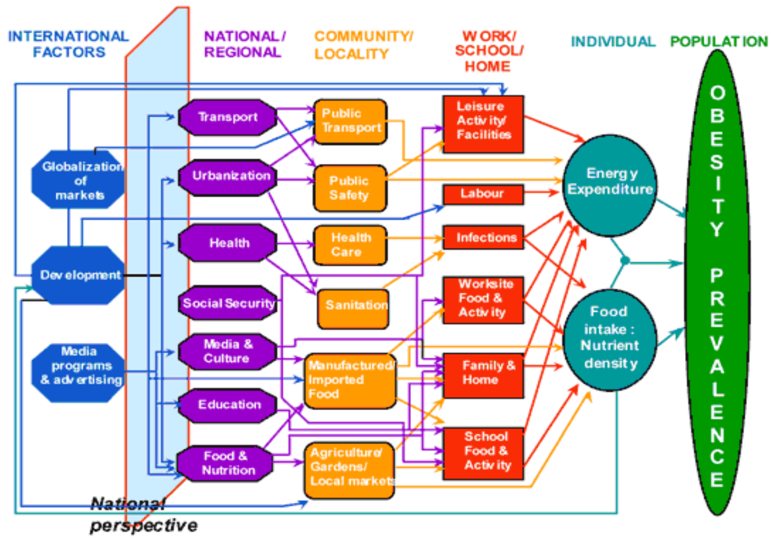

Fig. 2. Example of the complex system of systems related to obesity (from [8])

Social and behavioral factors inform not only health choices but likely responses to policy interventions at every turn, from preferences (e.g., consumer choices) to satisfaction (e.g., with healthcare treatment options) to forms of resistance (e.g., to government policies) and beyond. The challenge is to understand how to merge the kinds of models amenable to modeling social factors – social network or agent-based models, for instance – with other forms of deterministic models. The model-integration problem becomes even more challenging when merging these behavioral models with other types of models, such as transportation models that help determine access to supermarkets or clinics, models of health facility utilization, or econometric models (see, for instance, [14]).

2.3 Challenges in the Social Practices of Modelers

Questions raised by consideration of the integration of social and behavioral models in understandings of health and health policy with other model types points to a broader set of considerations around the worldviews and social practices that inform the underlying assumptions of the models and the expectations of their application. In practical terms, we aim to understand what it will take to bring together contributors in ways that will support fruitful collaboration across diverse communities of experts and that lead to the production of meaningful and useful outputs. What enabling technologies and sets of practices will support the kinds of knowledge-production and decision-making requirements of users? Here we broaden the lens from the particulars of the social and behavioral models themselves to focus more on the meta-level practices of modelers and those who aim to benefit from their results. Our interest parallels that of the conference itself: We are asking what the operational considerations of the environment need to be to encourage experimentation and derive novel theories to help address the complex challenges of health and health policy.

Numerous investigators of the work of interdisciplinary innovation and development have identified the communicative, cognitive, and broader social challenges of creating meaningful exchange among scientific and other communities of experts. The notion of "trading zone" offers a compelling metaphor for consideration of how knowledge exchange across diverse scientific and technical communities occurs. Most famously associated with Galison's [5] description of how the distinctly different communities from engineering and science developed radar and particle detectors, the "trading zone" provides a means for recognizing how, despite potential misunderstandings (taking something to mean something other than what was intended) and mis-recognitions (thinking things mean the same when they do not), experimentation continues and communities manage to collaborate. Galison's and others' cases of how the trading zone operates highlight how languages developed by different communities of experts matter and must be accounted for. Star and Griesemer's [12] notion of "boundary object" adds a material and spatialized dimension of understanding to the picture. Boundary objects "are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable means of translations." [12, p. 393] This notion points to the fact that technical and scientific practice involves the manipulation of tangible *and* conceptual objects.

In considering how to establish productive interchanges between health and health policy researchers of varying backgrounds, and in particular where and how to integrate social and behavioral modeling approaches, we must recognize that the challenges do not concern only technicalities of modeling integration, but also concern establishment of the right environment for collaboration, including tools and terms of discourse. There are risks in not interrogating this aspect as we move ahead in model integration. Models and simulations are powerful social products in their own right, and while they can significantly advance understanding and compel action, they can also overwhelm and lead to ill-guided actions (see [15]). For example, Brailsford et al. [2] cite one example of a clash between communities in which healthcare clinicians objected to hospital operational models that were adapted from the manufacturing industry and retained too much manufacturing terminology; the clinicians felt that such models reduce people to "widgets in a production line" and are doomed to fail.

The fluency with and ability to critically engage with models and their results is sure to vary across participants in the health and health policy arenas. Based on an ethnographic study of climate modelers, Lahsen [11] argues that in many cases users of models are better able to maintain critical distance on the value and veracity of the model than the modelers themselves. Debates can emerge, for instance, when models aim toward providing answers to help refine existing policies (which may or may not be supported by the individuals and organizations engaged in the modeling efforts) as compared to when they aim to inform the creation of new policy. At stake are potential conflicts of interest and guarding of intellectual property, and such challenges are likely to play out through critical engagement with the very bases of the models.

A related set of challenges arises in considering the usage of an integrated system of diverse models such as Splash! Even assuming that the issues of differing vocabularies of discourse and conflicts of interest among modelers from different domains are overcome, a number of problems still remain. Suppose that Splash! succeeds in creating a cooperative platform with many diverse models cataloged in its repository. What factors and facilities are required for a newcomer to join in this community, integrate a set of models, and take action based on the results? What are the mechanisms for judging the value of individual models and specific model combinations? How is trust built among existing and newcomer community participants? One example mechanism is illustrated by the ManyEyes web site for data sets and visualizations [17]. In ManyEyes, participants may register, comment, blog, and provide ratings on data sets. Provenance of data is explicitly described in bylines associated with data.

Furthermore, even assuming the validity of each given model, how can a policy maker be assured that the outcome of an integration of trusted, expert models is itself scientifically valid and can be trusted sufficiently to make health system decisions or investments? That is, how can participant trust be transferred from the component models to combinations of such models? Can mechanisms such as peer review, rating systems, blog discussions, certification by trusted authorities, etc., play a role in building such trust? Can a cooperative platform leverage or enhance existing technologies for model verification and validation? We intend to explore the opportunities and vulnerabilities of collaborative modeling in addressing these challenges.

3 Summary

As a dynamic and complicated system of systems, health continues to demand increasingly sophisticated understanding to encourage hopeful experimentation and development toward improvement. Determination of health policy and the ability to monitor effect and outcome is similarly complex. We aim to provide scientific support to these efforts by enabling engineering, synthesis, and integration of models of real-world systems to provide a means to try out possible alternatives through simulation. But this means we must account for social factors that underlie and inform health-related actions and outcomes. This paper raises and explores two sets of questions for advancing social and behavioral modeling: (1) how do we effectively integrate social and behavioral models with other models to inform complex systems understanding? and (2) how do we create the appropriate social environment to encourage participation by diverse individuals and organizations in this integration?

Acknowledgments. The ideas for Splash! were developed by a team at IBM Research – Almaden, including Christopher Campbell, John Day, Susanne Glissmann, Kelly Lyman, Ben Shaw, Susan Stucky, and Steve Welch.

References

1. Bahr, D.B., Browning, R.C., Wyatt, H.R., Hill, J.O.: Exploiting social networks to mitigate the obesity epidemic. Obesity 17(4) (2009)
2. Brailsford, S.C., Bolt, T., Connell, C., Klein, J.H., Patel, B.: Stakeholder engagement in health care simulation. In: Proc. Winter Simulation Conf., pp. 1840–1849 (2009)

3. Chaloupka, F.J., Powell, L.: Price, availability, and youth obesity: evidence from Bridging the Gap. Prev Chronic Dis. 6(3) (2009)
4. Collins, J.L., Marks, J.S., Koplan, J.P.: Chronic disease prevention and control: coming of age at the Centers for Disease Control and Prevention. Prev. Chronic Dis. 6(3) (2009)
5. Galisoen, P.: Image & logic: A material culture of microphysics. The University of Chicago Press, Chicago (1997)
6. Hammond, R.A.: A complex systems approach to understanding and combating the obesity epidemic. Brookings Institution, Washington (2008)
7. Homer, J., Milstein, B., Wile, K., Trogdon, J., Huang, P., Labarthe, D., Orenstein, D.: Simulating and Evaluating Local Interventions to Improve Cardiovascular Health. Prev. Chronic Dis. 7(1) (2010)
8. Huang, T.T., Drewnowski, A., Kumanyika, S.K., Glass, T.A.: A systems-oriented multilevel framework for addressing obesity in the 21st century. Prev. Chronic Dis. 6(3) (2009)
9. Institute of Medicine and Robert Wood Johnson Foundation: Workshop on Unintended Consequences of Health Policy Programs and Policies (2001), `http://books.nap.edu/openbook.php?record_id=10192&page=15#p200049679970015001`
10. Kumanyika, S., Jeffery, R.W., Morabia, A., Ritenbaugh, C., Antipatis, V.J.: Public Health Approaches to the Prevention of Obesity (PHAPO) Working Group of the International Obesity Task Force (IOTF). Obesity prevention: the case for action. Int. J. Obes. Relat. Metab. Disord 26(3), 425–436 (2002)
11. Lahsen, M.: Seductive Simulations? Uncertainty Distribution around Climate Models. Social Stud. of Sci. 35 (2005)
12. Star, S.L., Griesemer, J.: Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. Social Stud. of Sci. 19(4), 387–420 (1989)
13. Sterman, J.D.: Learning from Evidence in a Complex World. Am. J. Public Health. AJPH.2005.066043 (2006)
14. Tu, T.T.: The Development of a Hybrid Simulation Modelling Approach Based on Agents and Discrete-Event Modelling. PhD thesis, University of Southampton (2008)
15. Turkle, S.: Simulation and Its Discontents. The MIT Press, Cambridge (2009)
16. van Meijgaard, J., Fielding, J.E., Kominski, G.F.: Assessing and forecasting population health: Integrating knowledge and beliefs in a comprehensive framework. Public Health Reports 124 (2009)
17. Viégas, F.B., Wattenberg, M., van Ham, F., Kriss, F., McKeon, M.: ManyEyes: A site for visualization at Internet scale. IEEE Trans on Visualization and Computer Graphics 13, 1121–1128 (2007)