Five promising methods for health foresight

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Abstract

Purpose – *This paper aims to show through empirical examples how five foresight methods have provided value in medicine and global health, and to argue for greater use of health foresight.*

Design/methodology/approach – *Through evaluation, literature search, and personal experiences, five approaches were identified where health foresight has shown strong value: forecasting, scenario planning, Delphi, technology roadmapping, and mass collaboration. For each approach, compelling examples are given, and usage and potential discussed.*

Findings – *There is great opportunity to learn from and expand on past successes, and to customize foresight methods to help decision making in medicine and global health. The range of novel applications to date provides clear evidence that applying foresight methods to health can help prepare for the future, including development of policy and health interventions.*

Research limitations/implications – *Metrics for the impact of health foresight are not widely used, and could be a focus of future research.*

Practical implications – *By seeing compelling examples of diverse foresight methods in medicine and global health, readers will be better equipped to improve health systems and interventions, and prepare for future public health incidents.*

Originality/value – *The paper brings together discussion of a range of health foresight success stories, and suggests potential customizations of foresight for the health field. Readers who are health professionals or involved in making policy for health systems will gain a toolbox for creative planning. Readers who are foresight professionals will gain a better understanding of which foresight methods have shown value in medicine and global health, and potential refinement of foresight techniques for health applications.*

Keywords *Health and medicine, Delphi method, Forecasting*

Paper type *Research paper*

1. Introduction

Preparing for the future is a necessity for every health policy-maker, practitioner, and scientist, whether developing policy, treating patients, or creating new products in a lab. A growing toolkit of foresight methods can help – some technical, others narrative based; some oriented around experts, others around broad public participation (Glenn and Gordon, 2003; Lempert *et al.*, 2003; UNIDO, 2005).

Imagine you are developing a response strategy to an emerging infectious disease challenge, a point of care diagnostic device, or a more effective health intervention. How will these discoveries benefit the people who need them the most? How will the path look from idea to implementation?

In considering these questions, we analyzed numerous applications of foresight methods to the health field. These applications include the Global Health Forecasting Working Group's advances in improving demand estimation for health products; the UK Office of Technology Foresight project ''Infectious Diseases: Preparing for the Future'', cited by Google.org as a

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factor leading to a recent $2M US investment in a new disease surveillance network; and the ''Dark Winter'' exercise of 2001, which simulated a covert smallpox attack on the US.

We have drawn examples preferentially (but far from exclusively) from the global health field, due to their lesser discussion to date in the scholarly literature, their illustration of the value of foresight methods for challenging settings, and the authors' personal experiences in applying foresight for global health. Examples were chosen from a combination of literature review and authors' personal experiences – all three authors are health professionals, and two are also foresight professionals. Inclusion criteria were the impact of the foresight work (estimated future impact in the case of recent examples), the availability of implementation details, the relevance to the foresight methods being discussed, and the opportunities as assessed by the authors for building on the examples for future health foresight efforts.

We discuss applications of foresight methods to health, including personal experiences from major projects that the authors have led. We review five approaches where health foresight has empirically shown strong value: forecasting, scenarios, Delphi, technology roadmapping, and mass collaboration.

For each approach, we give examples and discuss use and potential (see Table I for a summary of strengths and weaknesses of each method, and when each might be used). These five approaches are not mutually exclusive, and several instances are discussed where they are combined. We conclude with an example of how the five methods might each add value in a hypothetical emerging disease threat scenario, and discussion of the implications of these methods for research and society.

A note is in order about how applying foresight to medicine and global health differs from applying foresight to other areas. Health care has a number of aspects that make it special. There are many different stakeholders with different interests, including scientists, technology developers, doctors, patients, funders, and the pharmaceutical and biotechnology industries. The applicability of health care is universal as everyone interacts with health systems, yet there are widely varying demographics for health care, such as the elderly, or low-income populations in developing countries. Risk-pooling is critical to pay for health care, with individuals without access to such mechanisms at high risk of catastrophic health or financial setbacks.

Table I Comparison of five foresight methods for health

Method	*When should I use it? What's the ''product''?*	*Strengths and weaknesses*
Forecasting – trend analysis	You have a model and enough data to extrapolate Product: quantified forecasts, often with error ranges	+ Statistical and modeling tools to draw on – Many domains cannot be modeled quantitatively
Scenarios – stories about plausible future worlds	You want to get a qualitative range of plausible outcomes Product: narratives that span a range of plausible futures	+ Possible future worlds that can expand range of thinking – Requires good facilitation and diverse experts; difficult to evaluate plausibility of results
Delphi – a ranked list of options	You want to combine the insights of experts on a well-defined question Product: consensus answers, often ranked	+ Concrete consensus answers, and transparent process – Time-consuming; seldom creates out of the box results
Technology roadmapping – a blueprint for making a technology a reality	You want to understand implementation steps for a technology Product: a detailed roadmap with narrative and technical elements	+ A plan for getting ''from here to there''. Network of experts as side benefit – Significant funding and time. Plan may not be robust to future developments
Mass collaboration – barrier-free collaboration, at any scale	You want to leverage technology and structure interactions for better collaborations Product: tested tools and processes, new kinds of foresight outputs, and public engagement	+ Many promising prototypes. Tools keep improving – Tough to change entrenched social habits. Tacit knowledge needed for best interactions

These health-specific aspects affect the application of foresight to health in several ways. First, factors can be ranked into a rough spectrum according to their uncertainty, and then methods chosen according to how uncertain the factors of interest are – extrapolations where demographic change are the main variable of interest are much more tractable than responses to unpredictable events such as novel zoonotic illnesses. Secondly, the global nature of many disease threats and opportunities makes purely local approaches less applicable – when new pandemics and their solutions can arise and rapidly spread from around the world, a global approach must be taken, even if only to set the context in which a local foresight exercise is done. Third, financial factors play a key role in decision-oriented health foresight – in terms of affordability of health care relative to other priorities, funding and appropriate reward mechanisms for new health technologies and services, and differing financial interests of different players in health care ecosystems.

One other salient feature of health is its core importance to every human being – the absence of health, as of physical security, quickly becomes a paramount concern to be resolved. This implies that health threats can rapidly become the primary concern of societies, just as terrorist threats have become on many occasions. Foresight methods that hope to be capable of addressing such explosive concerns must be designed to accommodate and incorporate the immense pressures that any real large-scale health emergency will cause. They also face a tension between balancing preventive elements with treatment elements, and dealing with the statistical and abstract nature of some health threats.

We turn now to consideration of the individual foresight methods. Whether for a scientist interested in how to bring her discoveries to end users, a policymaker understanding emerging disease threats, a doctor looking at how the practice of medicine might evolve, or an entrepreneur leveraging technological advances for better health care, foresight initiatives share the same goal: how can we design desirable health futures? The goal is not to foresee what will happen, but to prepare for what might happen – and to develop a common understanding of what should happen if threats are to be mitigated and opportunities seized.

Foresight methodologies thus aid good decision making in the present. By understanding their relative merits, these methods can be customized for the health field – thereby developing a toolbox with which to design new health systems, improve existing ones, and prepare for future eventualities.

2. Forecasting trends

Use: to extrapolate trends for which a reasonable degree of confidence exists

Example. The Global Health Forecasting Working Group has studied how to improve demand estimation for health products. Good forecasting informs critical decisions like which drug candidates to invest in and how much production capacity to build – decisions that must be made years in advance of delivery. Such forecasting requires accurate data gathering, along with combining economic and health information into predictive models. It is also desirable to co-ordinate incentives between parties, and suggest ''decision points'' when the forecast should be checked against what actually happens.

By understanding plausible usage patterns for new health solutions, opportunities can be clarified for health product funders, developers, and manufacturers. One policy initiative suggested by the Global Health Forecasting Working Group was to create a neutral ''infomediary'', which would provide forecasting expertise based on collated information, and liaise between drug buyers and manufacturers to make the supply chain for medicines more effective for all parties (Global Health Forecasting Working Group, 2007). The infomediary idea has been endorsed by the TB Alliance and the Center for Global Development.

Discussion. Forecasting methods can reduce the uncertainty in extrapolating trends, highlighting plausible ranges. Many such forecasting methods exist, including time series

analysis, causal models, statistical analysis, pattern recognition, and game theory (Armstrong, 2001).

Some trends can be extrapolated into the future with a high degree of confidence: demographic momentum will cause aging populations and concomitant health needs for decades to come in many nations, including large developing nations like India and China (Chatterji *et al.*, 2008). Such trend extrapolation has been applied in the health field to understand the consequences of medical innovation for the future elderly, supported by construction of a ''Future Elderly Model'' that allows extrapolation of health impacts and costs under various assumptions (Goldman *et al.*, 2004). It has also been applied to applications such as estimating long-term savings from investing in health information technology (Girosi *et al.*, 2005), and to opportunities for global health diagnostics in a methodology which combines forecasting with elements of the roadmaps method discussed later (Burgess *et al.*, 2006).

Large-scale foresight projects can provide a ''backdrop'' to health-specific efforts, suggesting future trajectories that may provide new capabilities or impact population health. The State of the Future report is one such massive and regularly-updated effort, which tracks prospects for 15 Global Challenges including ''How can the threat of new and re-emerging diseases and immune micro-organisms be reduced?'' (Glenn *et al.*, 2008) It has been widely influential, not least because it specifically considers factors required for successful implementation of futures research.

Where trends can be extrapolated with reasonable probability, they can be combined with the other methods we discuss – methods often geared toward surfacing ''Black Swans'', i.e. low-probability yet high-impact events (Taleb, 2007). For example, if the emergence of a novel zoonotic illness is suggested as a potential public health risk, then forecasting based on known capabilities could used to work out consequences and feasible responses to this ''what-if''.

Bibliometrics (and more generally patent, literature, and Web scanning) can give a sense of R&D and resource shifts. In a widely cited study, Trouiller and colleagues identified that just over 1 percent of new chemical entities marketed in the last quarter of the twentieth century were for ''neglected diseases'' predominantly affecting the poor, making clear what the consequences of the status quo would be (Trouiller *et al.*, 2002).

Google.org's Flu Trends has implemented a method that infers and predicts influenza patterns using search queries, which has experimentally shown the ability to accurately estimate local influenza activity with a reporting lag on the order of one day (Ginsberg *et al.*, 2009). This could provide an independent estimator of local-level influenza activity that may provide more timely and fine-grained information than existing public health surveillance systems. The ability to see what is happening at local scales allows better forecasting at these scales. This ties in to increased opportunities for surveillance reporting globally, including in low-resource settings (Morse, 2007).

Enabling experts to collaboratively scan for innovations could act as an ''idea radar'' to look for emerging trends and out-of-the-box solutions. Imagine each expert being able to tag and comment on signals of emerging trends, and a system able to combine these individual insights – an early warning and opportunity system. The GPHIN system has successfully implemented a version of this idea, combining near real-time scanning of global media reports for events of public health significance with complementary human analysis; it was identified as a useful tool in the SARS epidemic of 2003 (Eysenbach, 2003).

3. Scenario planning

Use: to collaboratively create stories representing a range of plausible future worlds, and then ''back-cast'' to understand how those worlds can be sought out or avoided

Examples. The ''Dark Winter'' exercise of 2001 simulated a covert smallpox attack on the USA, to examine challenges that senior policymakers would face during a bio-terrorist attack initiating outbreaks of highly contagious disease. With a case-fatality rate of 30 percent and

high susceptibility in the population, the simulated consequences were both plausible and severe.

Realism was added through three successive National Security Council meetings set over a period of fourteen fictional days, with the 12 participants and 50 observers receiving information through a variety of briefings, special assistants, newspaper summaries, video clips, and participant-specific memos (O'Toole *et al.*, 2002). Five members of the US press corps observed, and ran a press conference session; other participants were high-ranking members of the US government. Decisions made by the participants were incorporated into the evolving scenario by the exercise controllers, so that later elements of the scenario evolved from key decisions made in earlier elements. Drivers used to create the scenarios were based on extensive analysis of epidemiological, security, disease-specific, and operational factors.

Through a combination of scenario development and role-playing, the exercise aimed to increase threat awareness among senior national security experts, and to improve prevention and response strategies. The exercise graphically illustrated likely challenges in vaccination strategy, civil liberties, and information flows. Results and findings from the exercise were disseminated through press conferences, publications, Congressional testimony, and presentations to relevant government and security experts; the briefing slides and exercise script were also made publicly available. Though differing from typical scenario exercises in its realism and depth, and combining simulation processes with the scenario elements, Dark Winter shared the methodology of building up plausible scenarios, understanding their consequences, and then back-casting to infer actions to be taken in the present.

Discussion. While forecasting is often a quantitative exercise requiring construction of detailed models, the method of scenario planning is more qualitative and narrative-based. It has evolved to help map uncertainty by building plausible future worlds under a range of reasonable assumptions, and then ''back-casting'' from them for policy relevance today, thus helping to think through strategies (Schwartz, 1996). The goal is not to predict what will happen, but to consider a range of possibilities: how might a flu pandemic play out? What if surveillance and point of care diagnostic technologies were deployed beforehand?

A good scenario planning exercise can last several days, using iterative exploration and discussion by a diverse range of stakeholders to gain insights on what contingent future worlds might look like – and what actions today can steer toward better futures tomorrow.

By bringing together people who are knowledgeable in relevant areas but do not normally talk, worldviews can be expanded outside the context of any single party – e.g. by getting Ministries of Health, philanthropic foundations, NGOs, and animal health experts all talking on the same wavelength. The method has been applied to the future of academic medicine (Awasthi *et al.*, 2005) and veterinary medicine (Willis *et al.*, 2007), to biomedical R&D (Institute for Alternative Futures, 2005) and genomics and society (Justman *et al.*, 2002), and to drug policy futures (Caulkins *et al.*, 2003) and health futures by the WHO (Garrett, 1999). Online systems may offer a way to run such workshops more economically and conveniently; a series of nanotechnology futures have recently been created in online collaboration venues[1].

Scenario planning is often applied when forecasting or other more structured methods cannot be applied – when too many unpredictable factors influence the outcome, or domain experience is weak. This spirit of preparing for uncertain yet plausible contingencies can be applied more broadly in thinking about the future; the key task ''. . . is to map uncertainty, for in a world where our actions in the present influence the future, uncertainty is opportunity'' (Saffo, 2007).

A key step in creating good scenarios is to define and bound uncertainties and identify the top drivers of change, so that informed imagination can be usefully applied to uncertain yet plausible contingencies. A scenario for the evolution of a national health system, for example, might consider aging, lifestyle changes, environmental change, pandemics, the emerging innovative countries, and technology innovation, among other factors. ''Integrated

visions'' based on similar drivers have been created for health and social services in the European Union (Saritas and Keenan, 2004).

Scenario planning can be combined with other foresight and modeling methods. RAND researchers have proposed a foresight framework for US health care managers that combines scenario-building to broadly map out plausible alternate futures of the US health care system with specific stress-testing modeling assumptions (Ma and Seid, 2006). This dual-approach framework lets foresight participants see what might break in a particular business model, given a particular assumed scenario.

Proust once said, ''the real discovery consists not in seeking new lands, but in seeking with new eyes.'' The same present-day events can be interpreted for future consequences in quite different ways by different stakeholders (Ogilvy, 2002). Collaboratively-created scenarios have the potential to incorporate these diverse perspectives, resulting in a team visualizing possibilities for planning and technology development that no single team member could have thought of alone.

4. Delphi

Use: to combine the insights of a pre-selected group into a ranked list of consensus options, prioritizing solutions to a well-defined question

Example. In a well-known Delphi study that prioritized applications of biotechnology for health in developing countries, a consensus list of the top ten biotechnologies was generated, and the potential of each illuminated (Daar *et al.*, 2002). The top-ranked biotechnology, for example, was molecular diagnostics. A total of 28 scientists took part, of whom half were employed in developing countries, and the other half either from developing countries or experienced in global health. The Delphi's usefulness and limitations were reflected in Nobel Laureate Joshua Lederberg's Foreword to the study:

> This Delphi-like approach has the expected virtues and shortcomings of relying upon consensus, more appropriate for policy choice in translational research than in predicting avenues of creative discovery ... [It] offers few surprises – but authoritative assurance that there are enormous harvests to be expected from investment in by now well-worn paths to deal with infectious disease and the improvement of agriculture.

This Delphi study was a factor leading to one of the authors of this paper being invited to contribute to the formation of the Grand Challenges in Global Health Initiative, which itself used a Delphi-like process to identify 14 ''Grand Challenge'' areas which, if solved, could lead to more rapid progress against the global disease burden (Varmus *et al.*, 2003). The Grand Challenges in Global Health Initiative has since received over US$400M in funding.

Discussion. The Delphi method generates a ranked list of consensus options by gathering and iteratively ranking solution ideas from experts. Several rounds of questions are used, in each of which the previous round's solutions are fed back to all the experts for refinement and ranking; this promotes rethinking and cross-pollination of approaches. In contrast to scenario planning, Delphi generates more quantitative and specific results. However, proposed solutions are less detailed, and typically less ''out of the box''.

Factors critical to the success of a Delphi include picking the right participants, asking them the right questions, and doing the right analysis. The participants need to collectively possess a rare combination of breadth, experience, credibility, and insight. The questions asked of them should be of clear importance, with a variety of possible approaches. And effective analysis serves to deepen and cluster suggested approaches, focusing attention on salient distinctions.

The Delphi method has been used to prioritize medical research and interventions in Europe, leading to increased co-operation among participants, and the bringing together of actors who would otherwise not collaborate (Wild and Torgersen, 2000).

One weakness of Delphi processes is their episodic nature, occurring as they do relatively infrequently. To overcome this weakness, a permanent ''Delphic oracle'' might be used:

diverse domain experts, each of whom had agreed to be ''on call'' for Delphi-type questions in the health sphere. Subsets of these experts could be utilized for particular questions, with results remaining online for others to build on or refer to. An existing partial prototype is ''real-time Delphi'', which is roundless and feeds expert answers back to participants in real time[2].

A method related to Delphi which has this ''persistently online'' character is Idea Futures, also called Prediction Markets. The method combines diverse opinions by opening up statements and claims to a large group, and using a market-based approach to create an ongoing ''price'' for each claim (Miles, 2008). As in futures and option markets, claims pay off after some set period if given conditions are true. For example, one might trade claims on ''Will an effective Malaria Vaccine be developed by 2015?''

Proponents claim that, by using markets with appropriate participants, price signals can reflect a robust, ongoing estimate of the likelihood of important events occurring. A counterargument is that real futures markets have mis-signaled important events that in hindsight may have been predictable. If conditions under which the method works are clarified, then this could be an out-of-the-box way to bring in a range of opinions on future health advances.

An experiment is underway on influenza prediction, the Iowa Electronic Health Markets. It has shown early promise, including some predictive ability regarding the evolution of influenza outbreaks at the level of a state roughly two to four weeks in advance (Polgreen *et al*, 2007)[3]. This could give advance warning of an upsurge in influenza activity, allowing public health measures to be taken in advance.

One implication for medicine and global health of these examples is that there may be two natural time scales on which Delphi-like methods can usefully operate. The shorter time scale, as exemplified by the influenza prediction method, aggregates individual observations to give a more rapid sense of evolving trends. The longer time scale, as illustrated by the top ten biotechnologies and Grand Challenges in Global Health examples, distills patterns from expert opinion and analysis that help to shape goals for a field over a period of several years.

5. Technology roadmapping

Use: to bring key stakeholders together to map out what must happen to make a new technology a reality, with one output usually being a graphical map of actions required

Examples. The Malaria Vaccine Technology Roadmap summarizes 11 priority areas, such as developing a standard set of immunological assays and creating information-sharing tools. It then discusses the rationale and high-level directions for each area, along with timelines, requirements, and enabling technologies (Kuehn, 2007).

The Malaria Vaccine Roadmap was guided by a Roadmap Working Group, with representatives of the Gates Foundation, Wellcome Trust, PATH Malaria Vaccine Initiative, and WHO Initiative for Vaccine Research. Workshops in the USA, the UK, and South Africa were held to develop action plans and seek feedback from the malaria vaccine community. In a final synthesis phase, key experts reviewed the collective input and results of the meetings, and recommended strategic priorities for investments.

An even more in-depth effort, the Detection and Identification of Infectious Diseases project from the UK Office of Technology Foresight, suggested ways to lessen the burden of infectious disease through detection, identification, and monitoring technologies[4]. Results included several technology roadmaps, region-specific assessments, and maps of future threats and technology potential (particularly in diagnostics and monitoring). Time horizons ranged from near-term to 20-year, with the analysis organized around four key ''user challenges'' such as ''high-throughput screening for infectious diseases of people, animals and plants''. This foresight project was explicitly cited by Google.org as a factor leading to a $2M US investment to establish a new regional disease surveillance network, called the Southern African Centre for Infectious Disease Surveillance (Stevens, 2008).

Discussion. As tangible outputs, the roadmapping process yields documents describing some subset of the following: the challenge(s) to be solved; key platforms, processes, and technologies required to reach solutions; diagrams, timelines, and milestones; investment requirements and resource estimates; technology and demand forecasts; and risk analyses.

An Asian roadmapping project has been conducted to understand the potential of new technologies to combat emerging infectious diseases (APEC Center for Technology Foresight, National Science and Technology Development Agency, 2008).

The International Technology Roadmap for Semiconductors is perhaps the best-developed roadmap effort, with a new edition every two years:

> [T]he Roadmap has been put together in the spirit of a challenge – essentially, ''What technical capabilities need to be developed for the industry to stay on Moore's Law and the other trends?''[5].

Many hundreds of experts contribute, from industry, research organizations, and universities. And despite fierce competition in the semiconductor arena, the ITRS brings competitors together in precompetitive research for mutual benefit.

Technology Roadmapping is both a futures method and a consensus-building and resource mobilizing method:

> A roadmap describes a given future, based on the shared vision of the people developing the roadmap, and provides a framework for making that future happen technologically ... Technology roadmapping focuses not only on new enabling technologies, but also on the elements required to generate and support them. A technology roadmap might address technology transfer, marketing, finances, intellectual-property production, standards, and other issues[6].

As less tangible yet real benefits, roadmapping can yield a shared understanding of the problem space and a vision of how to solve it, a network of contacts, and ongoing formal and informal communication that helps move solutions forward – a point Phaal and colleagues make in their review and graphical taxonomy of roadmapping types, that may be particularly relevant in the global health arena with its diverse stakeholders:

> ... Many of the benefits of roadmapping are derived from the roadmapping process, rather than the roadmap itself. The process brings together people from different parts of the business, providing an opportunity for sharing information and perspectives and providing a vehicle for holistic consideration of problems, opportunities and new ideas (Phaal *et al*., 2004).

6. Mass collaboration

Use: to enable low-overhead collaborations by leveraging technology and innovative processes (a developing method in the context of health foresight)

Example. Leveraging gaming infrastructure and audiences, ''Serious Games'' are simulations with a game-like interface, that let thousands or millions of citizens experience a tough challenge and try various possibilities to solve it. A complex example is ''World Without Oil'', on a post-peak-oil future[7].

Superstruct has attempted to build on such games and create ''... the world's first massively multiplayer forecasting game. By playing the game, you'll help us chronicle the world of 2019 – and imagine how we might solve the problems we'll face''[8]. Played on blogs, discussion forums, videos, wikis, and other common online spaces, this combination of game and massively parallel simulation specifies broad parameters of the world as it might look in 10 years, and then relies on players to explore implications, suggest routes to reach or avoid particular outcomes, and react to each others' contributions. Superstruct combined over 7,000 players, and topped the ''Most Important Futures Work'' 2008 ranking of the Association of Professional Futurists.

Hybridizing such games with robust simulation could help health workers and scientists visualize how diseases and interventions might play out. Imagine being engaged with health

as if with a game, through enjoyable social interactions that let users learn about problems and work out solutions[9].

6.3 Discussion. How can today's social networking and collaborative technologies be leveraged to make collaborative health foresight easier and more scaleable? How can one enable ''the conversations that would be useful'' to happen? For example, how could animal health, human health, and agricultural communities engage in crosstalk more often, leading to discoveries like the correlation of a 1990s Ethiopian malaria epidemic with maize cultivation (McCann, 2005)?

Interdisciplinary workshops are a time-honored method, with one challenge being to convene the right mix of able and creative participants, and fully tap their insights. For example, a 2008 workshop focused on Global eHealth used a combination of low-tech (a relaxed setting, and scheduled time for many kinds of conversations) and high-tech (short interviews summarizing insights from thought leaders, that were placed online as created)[10]. Bringing together thought leaders and practitioners from developed and developing countries yielded many linkages for innovative technology trajectories and partnerships, from parties such as Rwandan President Paul Kagame and Rockefeller Foundation president Judith Rodin (Dentzer, 2008). These are mass collaborations in the sense that they structure interactions between relatively large numbers of people, to achieve creative discussion about health futures.

The medical field has many massive conferences, schools of public health, think tanks, and foundations, often with long time scales and large budgets. However, the unidirectional information flows of presentations or bidirectional flows of question and answer sessions do not qualify as truly ''collaborative'', for which large numbers of participants interact in relatively non-hierarchical ways, while still being productive in terms of overall group outcomes. As compared to conferences, productive conversations can happen in a more fluid way with minimal budgets, leveraging novel processes and technologies to let more people effectively collaborate than would be possible using traditional methods.

Facilitation can help great conversations happen (Kaner *et al.*, 2007), while real-time meeting systems can enable easy information exchange, interest matching, and ad-hoc meeting organization (McCarthy *et al.*, 2004). Informal conference sessions and ''speed talks'' can be spaces for sharing speculative possibilities[11]. ''HealthCamps'' enable self-selected participants to create an agenda during the conference itself with low pre-planning and expenditure, drawing from the ''unconference'' and BarCamp movements[12]. These methods – particularly the recent ones experimenting with self-organizing, low-overhead collaborative meetings facilitated by technology – suggest more efficient and effective possibilities for collaborative health foresight meetings.

Rapidly-growing technological capabilities are combining with lessons from social experimentation in collective problem-solving to enable productively harnessing many minds for solving tough challenges (Masum and Tovey, 2006). Health-specific social networking communities suggest what mass collaboration could enable through shared computational, surveillance, and visualization platforms[13]. Applications in the foresight context could include scanning for future possibilities and pitfalls, promoting peer communities through social networking, and enabling distributed simulation environments to test what-if scenarios.

Videoconference-enabled multi-site collaboration could enable health foresight across widely distributed locations, building on successful initiatives in other fields such as the MusicGrid project which implemented broadband video music collaboration across Canada and internationally (Masum *et al.*, 2005). There is a risk that such modes of interaction may preferentially empower youth (who are more familiar with the technology) over the elderly (who are more affected by health challenges), or similarly those with access to technology over those without. This risk can be mitigated through designing systems with a range of target users and technology experience levels in mind, and through facilitation to ease the user experience for the elderly. Systems have been successfully tested with the elderly for videoconferencing to lessen isolation (Savolainen *et al.*, 2008), and for a general e-health

platform to provide diagnostic monitoring, cognitive therapy, and social contact and entertainment (Botella *et al.*, 2009).

To scale this up, there is an opportunity for major funders to set up a high-bandwidth network of advanced videoconferencing sites, including key cities in the developing world (Conti, 2007). This could make collaborative visioning with citizens worldwide easier, thus involving those affected by global health challenges in the process of deciding how best to tackle them.

7. Conclusions

This article analyzed applications of foresight to health, gave a concise guide for making use of health foresight methods, and argued for greater use and development of these methods in medicine and health. With massive investments being made into new health technologies and interventions, and future developments like personal diagnostics and pandemics having enormous potential for good and ill, foresight methods can reveal hazards and attractive possibilities.

Returning to the first hypothetical situation posed in the Introduction, consider how the methodologies covered might be applied. Imagine you are developing a response strategy to an emerging infectious disease challenge. Forecasting might be used to estimate vaccine development time and likely demand, building on the work of the Global Health Forecasting Working Group. An interdisciplinary scenario exercise could suggest how this would impact clinical practice, emergency response teams, and citizen preparation, building on efforts like the Dark Winter exercise. Real-time Delphi might help to evaluate options from a group of infectious disease and response experts, or the Influenza Prediction Market example could be adapted for the new disease. Learnings from the ''Detection and Identification of Infectious Disease'' project might have informed previous preparatory capability building for national and international health systems, making the set of capabilities available more robust than it would have been without preparation. Finally, mass collaboration techniques could draw together interested parties worldwide to enable them to rapidly assess the situation, brainstorm options, and share response strategies – improving on the early collaborative techniques used worldwide in response to the SARS epidemic.

What are the implications of these methods for research and for society? On the research side, better and greater applications of health foresight can guide medical and health systems research toward solving challenges that may be ''over the horizon'' for the typical busy researcher, and yet relevant due to their likely emergence or potentially serious consequences. For example, the ''Detection and Identification of Infectious Disease'' project discussed above provides an abundance of specific cross-disciplinary research opportunities, which arose out of systematic consideration of foresight implications of a common question. Similarly, the Malaria Vaccine Roadmap suggests where biomedical researchers could focus their energies, and where supportive infrastructure might be provided to help all researchers function more effectively.

On the societal side, these methods can function as an ''early warning system'' to make threats and opportunities apparent early enough to prepare for them effectively. They can also involve the public at large in foresight exercises, particularly the last method which illustrates examples such as Superstruct and Healthcamp – examples which bring motivated amateurs into the process of elaborating future possibilities. Finally, these methods may promote a more proactive rather than reactive approach toward health policy; this may be aided by identifying specific examples of health foresight use that saved a health system significant funds, made it more effective, or saved lives directly through better emergency preparedness or clinical outcomes.

The future is an undiscovered country, but one which can be partially illuminated through disciplined evaluation. For the time-pressed foresight practitioner, medical researcher, or policymaker, using and adapting foresight methods to think constructively about the future can ultimately act as an aid to good decision-making in the present.

Notes

1. Center for Responsible Nanotechnology Task Force Scenario Project, available at: www.crnano.org/CTF-Scenarios.htm (accessed 24 June 2009).
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