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ARTICLE

A Foresight Analysis of Pervasive Healthcare Technologies

Thomas Gauthier
University of Applied Sciences Western Switzerland
Switzerland

Katarzyna Wac
University of Copenhagen
Denmark

Abstract

Inevitably, healthcare goes pervasive, yet its many potential future scenarios are still to be defined. We employ foresight techniques to define some of these scenarios, as relevant for the current and future state of healthcare in Geneva, Switzerland. We teach the methodology to undergraduate business administration students – potential e.g., managers and policymakers in the future healthcare system of Geneva. Our objective is twofold: to train students at scenario building and to develop scenarios for pervasive healthcare technologies and their social implications. Results include scenarios developed by the students as well as lessons learned with respect to the power of foresight techniques employed with novices in this field.

Keywords: Foresight, policymaking, healthcare system, scenarios, social implications, visionary thinking

Introduction

Healthcare is being profoundly impacted by societal trends such as population aging and shortage of trained medical professionals. Meanwhile, pervasive healthcare technologies, defined as ubiquitous computing in healthcare and for wellbeing, and innovative man-machine interfaces are offering unprecedented opportunities to deliver meaningful health and well-being products and services while possibly limiting health expenditures.

Several factors are likely going to influence whether and how pervasive healthcare technologies may reach their full potential including but not limited to users' expectations, usability and acceptability, delivery, etc. In turn, pervasive healthcare technologies may yield a range of social implications such as individual and caregiver empowerment, health behaviour changes, and so on. Hence it is critical to contemplate many possible futures to facilitate dialogue between groups with competing or conflicting visions and ultimately guide decisions and actions in light of those possible (and desirable) futures.

Scenario building is a rigorous foresight method that strives precisely to reveal social implications of changes to a *system of interest* (SoI), be it healthcare at a time of pervasive technologies (Godet, 2000). While several examples of health futures studies and scenario building exercises were featured as early as in 1995 in a special issue of Futures (Blackman, 1995), to our knowledge there have been no significant attempt so far at training and including non-experts as participants in scenario building workshops. The objective of research presented in this paper is to investigate whether scenario building (Börjeson, Höjer, Dreborg, Ekvall, & Finnveden, 2006) may prove helpful in assessing pervasive healthcare technologies (at large) by novices (yet potentially powerful actors in the future) introduced to this methodology and to identify the social implications of the scenarios developed in the context of Geneva, Switzerland.

Methodology

Participants and overview of methods

Sixty-five final-year Bachelor of Science in business administration students (aged 24±2.5 years, 40 males/25 females) were enrolled in a 13-week, 4h/week strategic foresight course. They represent a generation of potential future policymakers, managers and other actors in Geneva.

Students were asked to self-organize in 20 groups of 3-4. They first received a general introduction on strategic foresight as well as a more detailed and practical training in (1) structural analysis (Arcade, Godet, Meunier, & Roubelat, 1999) and (2) scenario building methods (Godet, 2000; Jouvenel, 2000; Durance & Godet, 2010). Students also attended (3) 1 to 2h-content provision sessions, i.e., expert conferences on emerging healthcare technologies, public health policies and challenges in Geneva, and public administration practical foresight experience in nearby Lausanne. The overall foresight process provided to students is summarised in Figure. 1.

Structural analysis

Structural analysis is a systematic, matrix-based method aimed at revealing and investigating relationships between those variables that define a SoI and its environment. It focuses primarily on most influential and/or dependent variables that are critical to explain how a system may evolve.

Each student group analysed "healthcare in Geneva" as the SoI and included the following ten variables in the structural analysis: (1) population, (2) *megalopolis* (i.e., intensified urbanization), (3) employment and qualification, (4) public finance, (5) social and public health policies, (6) *homo numericus* (i.e., ubiquitous connectivity), (7) social networks, (8) priceless health (climactic health consciousness), (9) world economic situation, and (10) endangered ecosystem. The principal investigator provided the variables based on own experience in the field and the context of the healthcare system in Geneva.

Relationships between variables were then reported in structural analysis matrices (one per group) (Table 1) where (*i, j*) = 0 (respectively 1) indicates that a variable *i* has no direct influence (respectively has a direct influence) on a variable *j*. Therefore the maximum influence/dependence of any variable is nine (it is considered that a variable does neither influence nor depend on itself).

Table 1. *Structural analysis matrix*

·	**Variable 1**	**…**	**Variable N**	**Influence**	**Type**
Variable 1	(1,1) ∈ <0,1>	…	(1,N) ∈ <0,1>	∑(1, j=1...N)	{Input, connecting, output, excluded, pack}
…	…	…	…	…	…
Variable N	(N,1) ∈ <0,1>	…	(N,N) ∈ <0,1>	∑(N, j=1...N)	…
Dependence	∑(i=1...N, 1)	…	∑(i=1...N, N)	·	

Each variable can be further classified as an input (high influence/low dependence), connecting (high influence/high dependence), output (low influence/high dependence), excluded (low influence/low dependence), or a pack variable. Input variables are considered as primary drivers of the SoI's dynamics. Whenever possible priority is given to act on input variables in order to impact the SoI. Connecting variables are such that any action on them may have repercussions on other variables as well as on themselves. Output variables are governed by actions of other variables, primarily input and connecting variables. Excluded variables are supposed to have little impact on the SoI and may be excluded from the analysis. Typical excluded variables include highly inertial variables that bear no impact on the SoI in the timeframe of interest. Lastly pack variables are insufficiently differentiated both in terms of influence and dependence. It is therefore challenging to draw any conclusion about their potential impact on the SoI.

Scenario building

At the conclusion of the structural analysis exercise, each student group chose among five topics the one it was going to develop alternative scenarios for. Topics included (A) the appointment at the general practitioner (GP), (B) the visit at the pharmacy, (C) quantified self, (D) home care, and (E) health insurance systems. Topics were jointly selected by the principal investigator and the executive director of the Geneva department of health in order to align the scenario building exercise with local public policy priorities. A long-term horizon (2024) was considered to explicitly allow for any structural changes to unwind.

Each group was then asked to present three alternative scenarios for the topic they had selected and submit a written report whose structure was inspired by that of the Vaud 2030 report (Organe de prospective du canton de Vaud, 2012).

The three alternative scenarios consisted in two highly contrasted (*technology-enthusiastic* and *technology-averse*) and 1 more plausible, in-between scenario (*middle ground*). Student reports included the following sections: (1) Definition(s) of the most critical terms used in their report to avoid any misunderstanding; (2) Key indicator(s) that policymakers, entrepreneurs, academics, etc. may monitor to assess whether a particular scenario is unfolding; (3) Baseline description of the current situation for the selected topic; (4) Key variables that are most likely to guide future developments in the context of the selected topic; (5) Three scenarios.

Key indicator(s)

Key indicators are quantitative metrics that may be directly measured or indirectly inferred from observations, interviews, extrapolations, etc. Furthermore their future trend (upward, downward, or stationary) between now and 2024 shall have a direct impact on the likelihood that one or several scenarios (among the three scenarios developed by each student group) will unfold or not.

Key variables

Key variables are those that are most likely to guide future developments of the SoI (i.e., healthcare in Geneva). They may include megatrends (changes that are typically slow to start off but whose influence may be considerable in the longer term) (Naisbitt, 1982), inflection points (time points at which trends change course), and weak signals (indicative of potential future trends) (Ansoff, 1975). Key variables are furthermore organized according to the PESTEL (political, economic, social, technological, environmental, and legal) macro-environmental factor analysis framework (Aguilar, 1967).

Scenarios

Each student group was instructed to develop three exploratory scenarios (recall: technology-enthusiastic, -averse, and middle ground) for a selected topic (A-E) that answer the question: “How may key variables develop and what may their consequences be on healthcare in Geneva?”

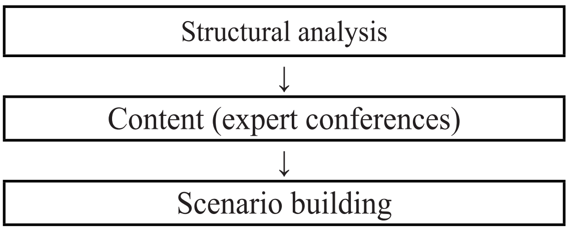

Figure 1. In-classroom foresight process

Results

Structural analysis

Once the structural analysis matrix was filled out by each student group, the mean influence and dependence were computed for each variable that in turn was tagged as either input, connecting, output, excluded, or pack variable (Table 2). It is worth noticing that five out of ten variables (*public finance, social & public health policies, priceless health, world economic situation, and endangered ecosystem*) were deemed insufficiently differentiated (both in terms of influence and dependence) pack variables. Therefore it is challenging to draw any conclusion about their potential impact on healthcare in Geneva. The most important variables are population, megalopolis and employment and qualification in Geneva.

Table 2. *Variables included in structural analysis*

Variable	**Influence** mean±std	**Dependence** mean±std	**Type**
Population	6.4±1.4	6.1±1.7	Connecting
Megalopolis	6.2±1.7	5.1±0.9	Input
Employment & qualification	6.7±1.4	6.3±1.0	Connecting
Public finance	4.8±**1.3**	5.7±**1.3**	Pack
Social & public health policies	4.6±**1.1**	5.9±**1.7**	Pack
Homo numericus	3.9±**1.7**	2.9±**1.1**	Excluded
Social networks	3.8±**1.0**	3.4±**1.1**	Excluded
Priceless health	4.4±**1.3**	5.3±**1.7**	Pack
World economic situation	5.4±**1.9**	4.4±**2.0**	Pack
Endangered ecosystem	4.7±**1.9**	5.6±**2.0**	Pack

Scenario building

Seven student groups chose to develop scenarios for the selected topic of an appointment at the GP office (A), four the visit at the pharmacy (B), five Quantified self (C), three home care (D), and one health insurance systems (E).

A preliminary set of key variables based on analyses by ten groups (seven working on (A) and three working on (B)) are presented in Table 3. The social factor PESTEL sub-categories were defined by the principal investigator. No variable suited neither political nor environmental factor. The number in brackets represents the number of groups across which the given variable has been identified. The arrow on the left side of each variable represents the trend (upward, downward, or stationary) that was identified by the student groups for that variable.A summary of the sets of three alternative scenarios is presented in Table 4.

Table 3. *Scenario building: key variables*

Economic	Social				Techno-logical	Legal
	General individual behaviour	***Health-related individual behaviour***	***Healthcare providers***	***Demo-graphics***		
↗ Health insurance premiums (2)	↗ Hyperactivity and stress (3)	↗ Self-diagnosis and self-medication (7)	↗ Shortage of GP (8)	↗ Aging population (8)	↗ Electronic health records adoption by healthcare pros (3)	↗ Public request for privacy laws (2)
↗ Healthcare spendings (1)	↗ *Homo numericus* (3)	↗ Natural and alternative medicine (4)	↗ Demand for visit at GP (2)	↗ Population (1)	↗ Wearables (4)	
↗ City's public debt (1)	↗ Burn-outs (2)	↗ "Health as capital" perception (2)	↘ Financial incentives for GPs (1)	↗ Age-related diseases (1)	↗ Smartphone health apps (3)	
	↗ Gamification (1)	↗ Mistrust in medical diagnosis (1)	↗ Number of health centres (vs. private GP offices) (1)	↗ Burden of chronic diseases (1)	↗ Automation and robotization (1)	
	↗ Do-it-yourself (1)	↗ Prescription and over-the-counter drug consumption (1)	↗ Initiatives to promote collaborations between GPs and pharmacists (1)		↗ Research and development in intra-body sensors (1)	

Table 4. *Scenario summaries*

Scenario 1 (technology-averse): “One nation - one health” - Same health insurance premium for all
This scenario builds upon the hypothesis that pervasive healthcare technologies (including connected wearables) don’t scale and people are reluctant to transfer health data to their insurance company. It also assumes that individuals take pride in contributing to a healthcare system based on solidarity. In scenario 1, there will be a unique health insurance fund that offers three levels of coverage. Level 0: basic health insurance (mandatory) Level 1: basic health insurance + complementary health insurance option 1 (e.g. oral health, ophthalmology, medications not reimbursed within level 0 coverage, emergency care abroad, etc) Level 2: basic health insurance + complementary health insurance option 2 (complementary health insurance option 1 + alternative medicine, partial/full fitness center membership, etc) Individuals will pay a fixed percentage of their combined income (including but not limited to salary, retirement/pension, social benefits, etc) based on the desired health insurance level. The higher the health insurance level, the more expensive the premium will be. Same percentages will apply to all. Individuals above 18 with insufficient income will pay a fixed premium until their income reach a set threshold (to be determined). All individuals who chose a given health insurance level will have access to the same benefits as their peers who chose the same level. In particular, no difference in benefits will be applied based on age and health status. In today’s Swiss health system individuals are segregated based on age and they may tune their premium to adjust their deductible. For this scenario to unfold, the Swiss people will have had to vote in favor of a law that would enact a unique health insurance fund. Until now, several *initiatives populaires* (people-led votes in the Swiss direct democracy system) have been rejected. However, results from the latest (September 28 2014) vote showed that the majority of French-speaking Swiss cantons’ inhabitants were in favor of a unique health insurance fund. A possible future development would be that individual cantons such as Geneva establish their own canton-level unique health insurance fund. As a consequence, private health insurance companies’ business would likely be at least harmed in the aforementioned cantons while wealthier individuals may see their premium increase and their benefits stagnate at best.

Scenario 2 (middle-ground): "Data for discount" - Voluntary data sharing in exchange for a premium discount
This scenario builds upon the hypothesis that pervasive healthcare technologies scale and many people are willing to transfer health data to their insurance company in exchange for a premium discount. It also assumes that individuals take pride in contributing to a healthcare system based on solidarity. In this scenario, the health system would resemble today's Swiss health system except that individuals will be able to opt in a data sharing program on a voluntary basis. Individuals will still be segregated based on age and they will still be able to tune their premium to adjust their deductible. Scenario 2 introduces a new option for individuals aged 15 and over to choose between a regular premium and 2 options that may both yield a premium discount for the insured. Option 1: the insured is willing to wear a connected wristband (or some other kind of wearable) and to share her data with her health insurance company. The health insurance company then sets one or several measurable healthy living goals such as a minimum number of steps per day. Depending upon reaching her assigned goals, the insured is rewarded with a personalized premium discount. Option 2: an insured who chose option 1 may switch to option 2 by partnering with another insured whose risk profile is higher for the health insurance company (the exact details on how an individual's risk profile is established are out of scope). High risk profile individuals may include elderly people, chronically ill patients, etc. Now both insured (regular and high risk profile) are wearing a connected device. The high risk profile individual will be coached by her regular risk profile partner in an effort to achieve a healthier lifestyle. The regular risk profile insured is still assigned measurable healthy living goals by her health insurance company while the higher risk profile insured is assigned less stringent albeit progressive measurable healthy living goals. If both participants reach their goals they are both rewarded with personalized premium discounts. The regular risk profile insured's discount is more attractive than the corresponding option 1 discount to reward the successful coaching duty. Individuals who are unfit to walk or engage in other types of physical activity can't sign up for either option and are automatically enrolled in the regular health insurance program.

Scenario 3 (technology-enthusiastic): "Survival of the fittest" - Segregation based on individual lifestyle
This scenario builds upon the hypothesis that a growing number of individuals become health conscious and are willing to transfer personal health data to their insurance company in exchange for a premium discount. It also assumes that individuals grow more self-centered and individualistic. All individuals aged 15 and over will be equipped with a connected device (e.g. wristband). The device will record and transfer health data to their insurance company. Data may include but not be limited to blood sugar, physical activity, quality of sleep, presence of legal and illegal harmful substances in the individual's blood (e.g. alcohol, nicotine, drugs, etc), etc. Individuals will then be assigned a group based on their personal data. Group 1: highly active, health conscious individuals (the exact details on group 1 inclusion criteria are out of scope; they may include but not be limited to level of physical activity, quality of sleep, dietary habits, etc). Group 2: health conscious individuals with occasional alleged unhealthy behavior. Group 3: inactive and unhealthy individuals. The number of groups (three) is arbitrary and only illustrates the concept of data-based health risk profile. Kids group: children aged 15 and less are all enrolled in the same health insurance plan. Group 0: individuals who suffer from at least one chronic disease at the time they are enrolled in a health insurance plan (15 years of age). Each individual will pay a premium based on her group membership. Premiums will be collected at a group level and used to finance that group only. Group 1 members will pay the lowest premium while group 0 members will pay the highest premium. When a group member becomes ill, the group health insurance fund will cover her health expenses. However, if a group member adjusts her lifestyle (as evidenced by data), she may be assigned to another group (either healthier or less healthy depending on her lifestyle adjustment).

Discussion

Structural analysis

The results of the in-classroom structural analysis bring up several interrogations. First and foremost 5 out of 10 variables included in the structural analysis were deemed insufficiently differentiated (both in terms of influence and dependence) by the students. Such a high proportion of pack variables may signal that students did not fully understand the definition of at least those 5 variables and/ or their potential impact and dependence on healthcare in Geneva. The structural analysis also revealed counter-intuitive results such as homo numericus and social networks being considered as excluded variables, i.e., having little impact on the system and being potentially excluded from the systemic analysis.

Aforementioned interrogations and counter-intuitive results may be explained by the timing of the in-classroom structural analysis. The exercise took place prior to conferences on emerging healthcare technologies, public health policies and challenges in Geneva, and public administration practical foresight experience in Lausanne. This may stress the importance of providing novice participants in a collaborative scenario building process with enough background knowledge and contextual information to be able to proceed with identifying, analysing, and integrating key variables in scenarios.

There are additional limitations to structural analysis. It does not offer unique or "validated" definitions for key variables (and relationships between them). Therefore, the participants come up with their individual and collective interpretations. In this sense, structural analysis does not define a reality but is merely a means to observe it via subjective interpretations.

Key variables and scenarios

Key variables presented in Table 3 are indicative of agreements and tensions between individual perceptions of social, economic, technological, and legal key variables. Such agreements and tensions will serve as the basis for developing scenarios. Moreover, some variables are highly specific to healthcare in Geneva, or even in Switzerland like high insurance premiums, emphasis on privacy laws or prevalence of hyperactivity, stress and burnout across the ageing population experiencing shortage of GPs.

Scenario 2 and scenario 3 are raising ethical concerns related to various ways of segregating individuals e.g. based on their physical condition. Scenario 3 requires that society agrees to sort individuals based on their lifestyle. While such a collective *modus operandi* may encourage healthier individual *modus vivendi*, it may also contribute more stress to an already alleged stressful society.

Social implications

From Table 3 we observe that students considered that individuals are increasingly digitally connected with each other. However this trend was not considered to be influential in the earlier structural analysis. Change in students' mind may be explained by the expert conferences that took place between the structural analysis and scenario building exercises. Pervasive healthcare technologies could have the potential to promote more efficient relationships with healthcare professionals such as GPs. For example, self-diagnosis could become a prime entry point into the healthcare system by connecting the individual with the most relevant healthcare professional given the self-diagnosis results. Instead, self-diagnosis may lead directly to self-care and thereby mitigate the need for healthcare professionals' intervention.

Individuals are increasingly connected in an increasingly active and stressful society. While ubiquitous technology may contribute directly to such active and stressful society, it may concomitantly albeit paradoxically promote self-care and well-being.

While pervasive healthcare technologies may have the potential to contribute to individual empowerment (including self-diagnosis and self-medication), it is not clear yet how they will interact with the alleged renewed interest for natural and alternative medicine.

Aging population was the single most frequently cited key variable (8/10 groups). This may indicate that study participants recognized that elderly people are accounting for an increasing percentage of the population that furthermore will seek healthcare.

The future of GPs is notably unclear and preliminary key variables may lead to contradictory interpretations. For instance there seems to be no clear understanding of whether the current shortage in GPs shall become a public priority and trigger an increase in the number of trained medical students and GP graduates. Indeed hyperactive lifestyle may not allow for regular visits at the GP office anyway. Alternatively new healthcare professionals such as healthcare digital coaches may be more appropriate to assist individuals in their daily use of pervasive healthcare technologies (including wearables and health applications for smartphones). Coaches may also facilitate the flow of health information between individuals who may collect an increasing amount of data via quantified-self devices and services and professionals who may share information via electronic health records. Ultimately healthcare digital coaches may be responsible to establish and sustain a health information continuum between individuals and professionals.

Pervasive healthcare technologies may bear several social consequences such as accentuating the individual perception of health as capital and ultimately ostracising those who are reluctant to take charge in their own health. The increase in health insurance premiums combined with the drive of some to invest in living a physically active lifestyle and self-quantifying their workouts could trigger a desire to belong to a self-insured community of health conscious individuals.

Limitations

The foresight exercise described here is limited in that it did not feature any formal analysis of stakeholders and stakeholder relationships (Godet & Durance, 2011). Besides, the students did not receive any formal training in *morphological analysis*, which is the breaking down of the system under investigation into sub-systems combined with the systematic analysis of all plausible combinations of hypotheses. Therefore it was difficult to understand how each student group decided to focus on a selected topic (A-E) and 3 particular scenarios and which other topics/ scenarios were discussed internally within the student group. A proposed foresight process that includes stakeholder and morphological analyses is described in Figure. 2. It is inspired by the foresight process described in (Godet & Durance, 2011) with the addition of a “content (expert conferences)” block that aims at educating non-experts in the SoI.

From scenarios to strategic foresight

Thinking forward, the exploratory scenarios may be leveraged by the Geneva department of health as input into its strategy development processes. Scenarios may especially be helpful to guide the development of resilient strategies in an uncertain and possibly turbulent environment. A potential next step may be to involve the Geneva department of health together with the selected external stakeholders (including patients, healthcare professionals, and health insurance representatives) to develop strategic exploratory scenarios. Such scenarios incorporate the policymaking toolbox available to the intended scenario users (i.e., Geneva department of health executives) and allow possible consequences of hypothetical strategic policy decisions to be described, understood, and accounted for when shaping actual policy decisions.

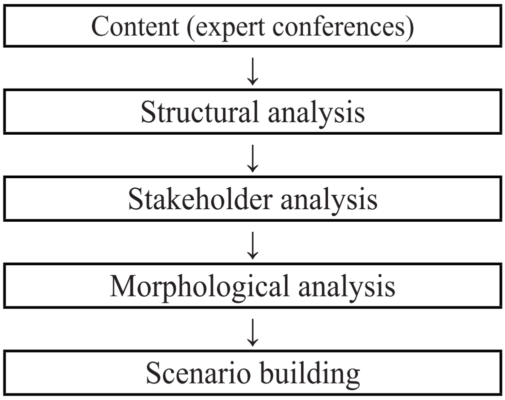

Figure 2. Updated foresight process

Conclusive Remarks

Collaborative foresight techniques, and specifically scenario building was proved feasible and useful in assessing variables important in the development of the pervasive healthcare technologies' and their potential social implications, at the individual, organizational, as well as population and policymaker level.

As we have shown, foresight methods are accessible to individuals with a Bachelor-level education in management. Putting forward collaborative scenario building skills in younger generations may enrich direct democracy processes and further engage citizens in critical public policy decisions not limited to health and technology. When citizens are actively contributing to foreseeing possible (and desirable) futures it is likely that they will act today to turn desirable futures into reality. In the end foresight is primarily concerned with enlightening present actions for the benefit of (a future) public good.

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Correspondence

Prof. Thomas Gauthier
University of Applied Sciences Western Switzerland
Route de Drize 7,
1227 Carouge,
Switzerland
Email:thomas.gauthier@hesge.ch

Katarzyna Wac
University of Copenhagen
Denmark
University of Geneva
Switzerland
Email: wac@di.ku.dk; katarzyna.wac@unige.ch

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