Med Health Care and Philos (2012) 15:61–77
DOI 10.1007/s11019-011-9312-5

SCIENTIFIC CONTRIBUTION

How do medical device manufacturers' websites frame the value of health innovation? An empirical ethics analysis of five Canadian innovations

P. Lehoux · M. Hivon · B. Williams-Jones · F. A. Miller · D. R. Urbach

Published online: 3 February 2011

Abstract While every health care system stakeholder would seem to be concerned with obtaining the greatest value from a given technology, there is often a disconnect in the perception of value between a technology's promoters and those responsible for the ultimate decision as to whether or not to pay for it. Adopting an empirical ethics approach, this paper examines how five Canadian medical device manufacturers, via their websites, frame the corporate "value proposition" of their innovation and seek to respond to what they consider the key expectations of their customers. Our analysis shows that the manufacturers' framing strategies combine claims that relate to valuable socio-technical goals and features such as prevention, efficiency, sense of security, real-time feedback, ease of use and flexibility, all elements that likely resonate with a large spectrum of health care system stakeholders. The websites do not describe, however, how the innovations may impact health care delivery and tend to obfuscate the decisional trade-offs these innovations represent from a health care system perspective. Such framing strategies, we argue, tend to bolster physicians' and patients' expectations and provide a large set of stakeholders with powerful rhetorical tools that may influence the health policy arena. Because these strategies are difficult to counter given the paucity of evidence and its limited use in policymaking, establishing sound collective health care priorities will require solid critiques of how certain kinds of medical devices may provide a better (i.e., more valuable) response to health care needs when compared to others.

Keywords Medical device industry · Health technology · Value proposition · Socio-technical features · Website analysis · Empirical ethics

P. Lehoux (✉)
Department of Health Administration, University of Montreal, and Institute of Public Health Research of the University of Montreal (IRSPUM), C.P. 6128, Succursale Centre-ville, Montreal, QC H3C 3J7, Canada
e-mail: pascale.lehoux@umontreal.ca

M. Hivon
IRSPUM, University of Montreal, Montreal, QC, Canada

B. Williams-Jones
Department of Social and Preventive Medicine, and IRSPUM, University of Montreal, Montreal, QC, Canada

F. A. Miller
Department of Health Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada

D. R. Urbach
Departments of Surgery, and Health Policy, Management and Evaluation, University of Toronto, Toronto, ON, Canada

Examining the corporate value proposition of medical devices from a health care system perspective

According to Boenink (2010, p.12), scholars in ethics can bring a significant contribution to health policy debates by examining how new technologies may shift, over time, the goals of medicine. Analysing such shifts can enable the "anticipation of ethical issues associated with emerging technologies, since they are already discernable in the visions preceding and guiding the development of these technologies." Within this perspective, we chose to analyse the perspective of Canadian manufacturers who have designed and are currently promoting five medical devices. Recognising that corporate websites have become powerful knowledge-transfer tools (Williams-Jones 2006) and an important source of information (and sometimes confusion)

for health care providers, decision-makers and the public, we examine how manufacturers, via their websites, frame the "value proposition" of their innovation, that is "the value created for users by the offering based on the technology" (Chesbrough and Rosenbloom 2002, p.533).

By examining this notion through an empirical ethics approach (Haimes 2002; Molewijk et al. 2004), which brings forward how actors themselves define and mobilise values, our goal is to reflect critically on the manufacturers' framing strategies from a *health care system perspective*. In so doing, we aim to help fill an important gap in the current literature on ethics, corporate strategies and health technology. While scholars have examined the ethical issues surrounding the use of specific health technologies (Einsiedel 2006), advocated for a better integration of ethics in Health Technology Assessment (Grunwald 2004) or examined the marketing strategies of pharmaceutical companies (Gagnon 2009; Gagnon and Lexchin 2008), very few analyses have considered how the marketing strategies of the medical equipment industry may exacerbate the policy challenges currently faced by health care systems. This gap in the literature is all the more surprising when one considers the extent to which new medical technologies have transformed physicians' and patients' expectations about the value of specific medical interventions and, more generally, of health care. Health technology has also pushed third-party payers (governments and medical insurers) to search for new processes to use when establishing priorities among competing health care needs. While every health care system stakeholder would seem to be concerned with obtaining the greatest value from a given technology, there is often a disconnect in the perception of value (e.g., what feature is valuable, or how important it is) between a technology's promoters and those responsible for the ultimate decision as to whether or not to pay for it (Woolf and Johnson 2005; Teutsch and Berger 2005). Alongside the cost of pharmaceutical drugs, it is now recognised that innovations in health technology (e.g., medical devices, diagnostics), consumer expectations and demands, and mounting costs are key factors threatening the financial sustainability of health care systems in both developed and developing nations. It is thus important to understand how corporate claims about the value of medical devices operate within and influence various stakeholders in the health policy arena.

Our comparative case study examines five medical devices that present different decisional trade-offs from a health care system perspective and that are targeted at different users. These medical devices include: (1) an optical molecular imaging device for breast cancer diagnosis and characterisation; (2) a catheter-based cryoablation treatment for atrial fibrillation; (3) a decision-support software to monitor and help reduce birth-related injuries; (4) a telemonitoring system for chronic care patients at home; and (5) a computer-assisted navigation system to support minimally invasive orthopaedic surgery. These five innovations were all developed during the past decade and their Canadian manufacturers are actively seeking to establish or expand commercialisation in the sought-after European and North American markets.

For each of these five cases, we examined how the corporate websites defined the innovation's value. Specifically we analysed the clinical, technical, structural and human problems identified on the websites, and the solutions that each innovation is supposed to offer. Our analysis shows that manufacturers' websites employ framing strategies that combine valuable socio-technical goals and features that resonate with a large spectrum of stakeholders, including physicians, patients, hospital managers and taxpayers. We recognise, but do not discuss in this paper, the fact that some of these goals may conflict (e.g., claims related to early detection of disease may contradict cost-reduction claims) or the trade-offs that patients, physicians and third-party payers are actually forced to make in practice (e.g., balancing the benefits and risks of proactive treatment approaches). In a context of continual and progressive innovation—as is often the case with the development of medical devices—few would argue that manufacturers have an ethical obligation or responsibility to make such trade-offs explicit on corporate websites (or in other publicity); nonetheless, our study suggests that the manufacturers' framing strategies may be hard to counter, given the paucity of evidence about health technologies and its limited use in policymaking (Lehoux 2006). In the current market environment where many innovations are competing for increasingly restricted health care budgets, it is important to recognise that manufacturers' websites are *not only* a means of advertising innovations; they are also vehicles for disseminating powerful rhetorical tools that can support the many (diverse) demands and interests of the large set of stakeholders involved in setting health policy.

Defining what constitutes the "value" of health innovation

In our modern, consumption-oriented world — leaving aside for the moment an ethical understanding of the term "value" — perhaps the most common understanding of a product's value can be summarized in a simple equation: value = quality/cost. According to Ramirez (1999), the marketing and management literature has traditionally relied on this definition of value, one that is closely aligned with the industrial era, such that value is defined from the customer's perspective: "value is what customers are willing to pay for" (Porter 1985, p.3). When it comes to

medical technologies (e.g., medical devices, diagnostics), however, this view fails to fully capture the complexity underlying the "markets" that are health care systems and within which health innovations are designed, regulated, promoted, adopted, applied and purchased. Unlike other innovations and consumer products, in the case of health technology there are multiple categories of customers who "pay" different types of cost (e.g., side effects, liability risks and reimbursement) and "accrue" different types of benefit (e.g., recovery, professional self-esteem, the health of workers, cost-savings).

Furthermore, the core transaction around a "health care product" invariably involves an asymmetrical relationship between a physician and a patient (Evans 1984). While physicians are generally "informed" customers and remunerated for their role in the transaction, patients are usually not in a position to "choose" the product nor do they pay for it directly (Faulkner 2008). Notable exceptions include developing international markets for direct-to-consumer genetic testing (Williams-Jones 2006) or assisted reproductive technologies (Smith et al. 2010), where manufacturers more or less explicitly try to frame individuals as informed and autonomous patient-consumer-purchaser. In the more common context of health care services, patients are increasingly well informed about various health care matters (e.g., through discussion *fora* and interest groups, health information websites), but it is still ultimately the physician's professional judgment that weighs in the decision about what technology to use. By its very nature, transactions involving the consumption of a health technology differ profoundly from transactions observed in other markets, where the consumer is most often also the purchaser. In addition, a definition of the value that medical devices bring to health care should acknowledge the complexity and multiplicity of the stakeholders' perspectives at play and of the dimensions to which they are likely to be responsive. Indeed, patients and their relatives, physicians, nurses, health care managers, governments, employers, third-party payers and taxpayers are all, ultimately, concerned by the value of health innovations. But within and across these categories, individuals vary in the type or quantity of value that they attach to the characteristics of a given medical technology, including its safety, efficacy, ease of use and impact on quality of life, and its effects on population health, health care systems and finances (Grunwald 2004).

It is thus worth exploring in greater depth the interface between values and health technology. Scholars in Science and Technology Studies (STS) argue that society and technology are necessarily co-constitutive of each other (Brown and Webster 2004), and that values are not only found in both, but they also interact and evolve over time through reciprocal social and technological change. Here, values are seen as cultural constructs, open to interpretation and negotiation (Boenink 2010). Such a conceptualisation suggests that values may rely on emotional appeals to a varying extent and may be more or less widely shared among individuals, groups, organisations or industries (Einsiedel 2006; Jasanoff 2005). For instance, while analysing how Canadian policymakers mobilised values in official policy documents, Giacomini et al. (2004) observed the diversity and the confusion that accompany such appeals to values; they classified these values into five categories: (1) goodness (e.g., quality, effectiveness); (2) physical entities (e.g., health system, programs); (3) principles (e.g., efficiency, equity, responsibilities); (4) specific goals (e.g., prevention, access); and (5) attitudes and feelings (e.g., compassion, well-being, respect).

For philosophers and ethics researchers, this classification may appear problematic because it neither specifies the theoretical underpinnings of the values at play nor does it weigh or rank their relative importance (Häyry 2003). Nonetheless, this kind of analysis has the advantage of showing how actors themselves define and mobilise values in the context of their practice. Such an analysis is consistent with what Haimes (2002) and Molewijk et al. (2004) define as an empirical ethics approach, one that aims to help improve moral theory and/or ethical analysis by using social science methods to generate insights into value-laden social practices. An empirical ethics approach can help "connect the empirical data with theoretical explanations" (Haimes 2002, p. 107), thereby raising "awareness of the implicit normativity *within* facts and technologies" (Molewijk et al. 2004, p. 70) in order to draw attention to the normative assumptions embedded in technological change in medical practice. Consistent with this approach, Boenink has shown how the ethical implications of progress in molecular medicine could be analysed by examining its promoters' visions. These visions include relatively specific normative claims regarding the reduction of disease, suffering and mortality, but also contain "images of future medical practice, of future patients (or healthy human beings, for that matter), and of society at large" (Boenink 2010, p. 14).

In our own study, we posit that medical device users and stakeholders *see* the value of health innovation through their own repertoire of values (Boltanski and Thévenot 1991), something that manufacturers are likely to recognise and so use on their corporate websites. That is, we argue that manufacturers of health innovations use their websites to *frame* what they think matters to their diversified audience, using a specific language, highlighting particular dimensions and providing certain facts. For instance, when examining the content of corporate websites that offer direct-to-consumer nutrigenetics tests and DNA-based

nutritional advice, Saukko et al. (2010) derived dominant frames regarding how each company defined: (1) the nature of genes and tests; (2) the role of individual *vis-à-vis* genetic information; and (3) the advice and treatment it offered. These authors argued that in order to be successful, frames "have to resonate with contemporary social sensibilities, and they are often produced through subtle cues that suggest the meaning of the issue" (p. 747).

The focus of our study is on the framing strategies that Canadian manufacturers use to articulate the value proposition of their technology, and specifically how the technology creates value for potential users and purchasers (Chesbrough and Rosenbloom 2002). As underscored by Normann and Ramirez (1994), the perceived value of a product will be influenced by its ability to *complement* and *extend* users' competencies by enabling them to engage in new kinds of activities associated with its use. This observation led Ramirez (1999) to further refine the idea that value is not to be found in the object itself; rather, it is embedded in the meaningful activities that the object helps bring about. Consistent with an STS approach to technology that recognises that values may reside in both the social and material domain, we argue that a value proposition may refer to valuable socio-technical *goals* (i.e., social and technical outcomes that may be attained through the use of a medical device) and *features* that are posited as valuable in themselves (i.e., social and technical properties embedded by design in the use of a medical device (Akrich 1995)).

To summarise, we argue that manufacturers are likely to use their corporate websites to intentionally frame the value proposition of their innovations. That is, manufacturers know and use the fact that their value proposition will be interpreted in light of innovation users' and stakeholders' aspirations and goals, and the sacrifices and trade-offs that will have to be made in order to acquire the innovation. Our analysis pays attention to the valuable socio-technical goals and features of an innovation as they are presented on manufacturer websites, goals and features that refer not only to the innovation itself but that also encompass the broader set of activities that the innovation helps make possible. Physicians, patients and other stakeholders are key audiences for medical device manufacturer websites, thus one should expect—and evaluate critically—the use of promotional strategies that combine scientific rationality and emotions, technical virtuosity and symbols of hope, which taken together evoke both functional and symbolic value (de Chernatony et al. 2000; Einsiedel 2006). It is clearly in the interests of medical device manufacturers to frame the value of their innovations in ways that are most advantageous for their businesses; but it may also be in the interests of other stakeholders, notably health policy makers, to examine and even sometimes contest the framing of medical devices and other health innovations.

Methods

The five medical devices used for our case study were identified and selected in the context of a broader research program (that began in 2008) that is examining how the designers of these innovations define and address the needs, expectations and constraints of users (clinicians and patients) and of health care system stakeholders. The medical devices include:

1) an optical molecular imaging device for diagnosing and characterising breast cancer (Innovation 1: Softscan™[1]);
2) a line of cryoablation catheters for the treatment of arrhythmia disorders (Innovation 2: Freezor™, Freezor *Xtra*™, Freezor *MAX*™);
3) a decision-support software to monitor prolonged labour and abnormal foetal heart rates and help detect birth-related injuries such as shoulder dystocia (Innovation 3: CALM Curve™, CALM Shoulder Screen™, CALM Patterns™);
4) a home telehealth solution comprising remote patient monitoring, disease management and a set of coordination tools to promote continuity of care for chronically ill patients (Innovation 4: Intelligent Distance Patient Monitoring™); and
5) a computer-assisted navigation system to support minimally invasive orthopaedic surgery such as hip, knee and spine implants (Innovation 5: Universal Knee Navigation System™, MIS Hip Navigation System™, Navitrack FluoroSpine System™, Navitrack Sesamoid System™).

These innovations represent a very rich set of cases for a number of reasons. First, they cover a large spectrum of clinical functions: diagnostic, therapeutic, decision-support, monitoring and imaging. Second, they are used in a range of medical specialties—cancer, cardiology, obstetrics, chronic care and surgery—and either in tertiary care or home care. Third, they raise different decisional trade-offs because they represent different types of innovation: partial or complete substitution to an existing technology, a new solution to unmet needs, or an incremental add-on to

[1] Our intent is not to promote specific corporate activities and products. We thus use numbers to refer to each innovation instead of repeating the names of either the manufacturers or their product. Because we quote directly from the corporate websites, both manufacturers and products are easily identifiable. We here mention brand names once, so readers who may wish to, can obtain additional information.

an existing technology. Finally, the Canadian small and medium-sized enterprises (SMEs) that designed these devices are strongly dependent on exports to North American and European markets and must, therefore, be responsive to the challenges of both private and public health care systems.

Our analysis is based on website content retrieved between October and December 2008.[2] In order to conduct an in-depth comparative content analysis, we transferred the website content of each of the five innovations into MSWord™ documents.[3] The textual data were then stored in the QRS NUD*IST™ data analysis software. We began by identifying themes that were common to the five innovations, and this initial open coding strategy (Strauss and Corbin 1990) generated very broad categories. Summary tables were created to compare the website content for each innovation based on this initial set of categories. These tables enabled us to further refine the categories, identify similarities and differences across the five innovations, and relate the categories to one another (axial coding). Finally, for the purpose of this paper, we focused our attention on four categories (selective coding) that captured key aspects of the manufacturers' value proposition, such as the technology's: (1) impact on clinical activities and outcomes (clinical dimension); (2) technical assets and comparison with current alternatives (technical dimension); (3) impact on work processes and health care structures (structural dimension); and (4) response to physicians' and patients' values, expectations and constraints (human dimension).[4]

Since our categories were refined iteratively, they are both empirically-derived and theoretically-informed. First, as mentioned above, a medical innovation is expected to bring value to *clinical* practice by extending physicians' and nurses' ability to mobilise and put to use their knowledge and skills (Ramirez 1999). Second, a medical device is supposed to possess *technical* assets; a company normally promotes its technology within the context of a competitive strategy, recognising that users' and stakeholders' judgments are formed in relation to what competitors have to offer (de Chernatony et al. 2000). Third, because the commercialisation of medical devices is strongly dependent upon the decisions of third-party payers, the benefits of a given medical device are often expressed in terms of its impact on health care *structures* such as team performance, hospital length-of-stay, cost of auxiliary services, etc. (Lehoux 2006). Finally, a health innovation may possess user-oriented features that seek to increase the *human* dimensions underlying its use (e.g., ease of use, personalised treatment, reduced invasiveness for patients).[5]

Some of the arguments we retrieved from the websites may of course belong to more than one category. For instance, "improving communication between physicians and nurses" could be considered a challenge related to both the human dimension (providing user-friendly tools adapted to both physicians and nurses) and the structural dimension (overcoming problems associated with nursing staff shortages). We therefore used a constant comparison process to refine our categories and classify each content item into the category that, given the overall rationale behind the innovation and its context of use, best reflected its relevance.

In order to describe how manufacturers frame the value of their innovation, we organised the empirical material into the four categories, created comparative tables and wrote our findings following two analytical steps. First, we conducted an *intra-case analysis* to answer, for each of the five innovations, the following two questions: What is the problem addressed? And what is the solution offered? This systematic questioning enabled us to identify, in a detailed manner, the claims made by each manufacturer to articulate their value proposition (Table 1) and the normative assumptions underlying each innovation (i.e., what needs to be corrected or improved, what is desirable or not) (Table 2).[6] Second, we then used an *inter-case analysis* to synthesize the valuable socio-technical goals and features on which manufacturers' framing strategies rely. This process of categorization allowed us to identify, for each of our analytical dimensions, the higher-level normative claims that the corporate websites put forward (Strauss and Corbin 1990), and that were common across the different medical devices (Table 3).

[2] By the time we had completed our analysis of the five websites, three of the five SMEs had been sold to larger companies. Four websites still exist, but their content has changed; there is no longer any website for Innovation 5.

[3] All downloadable documents, including videos, brochures, press releases, peer-reviewed publications and annual reports, were also indexed and downloaded but these will be analysed in a separate paper.

[4] A detailed table containing the verbatim website content is available upon request.

[5] Medical device R&D processes are increasingly seeking ways to increase interactions with users so as to better address "human factors," which provide greater insights into the context in which an innovation is used and into its users' needs, expectations and constraints (Vicente 2004). For instance, Nelson (1995, p. 1535), a physician working in the medical device industry, argues that it is by "working closely with physicians" that the medical device industry can design technologies that "save physicians time" and "improve the quality of life for patients".

[6] As one would expect, some of the arguments that we retrieved from the websites describe both the problem and the solution. For instance, when a website states that "reducing complication rates" is valuable, the implication is that complication rates are currently too high.

Table 1 The claims made on five manufacturers' websites that define the value proposition of their health innovation

Clinical dimension	Technical dimension	Structural dimension	Human dimension
Innovation 1: Optical molecular imaging device for breast cancer diagnosis and characterisation			
Problem	Problem	Problem	Problem
Estimates of morbidity and mortality	The use of mammography must be limited because of ionising radiation	Number of unnecessary biopsies	*For women*
Number of cases missed by anatomical imaging technique (mammography)	Information not provided by anatomical imaging (biochemistry, physiology, patient's response to therapy)	Costs associated to biopsies	Biopsies are painful
Patient sub-group who cannot be screened by anatomical imaging			
Solution	Solution	Solution	Solution
A new imaging technique that can better diagnose cancer, support research and eventually monitor treatment	Absence of ionising radiation	Ability to image patients as often as necessary	*For women*
Higher degree of precision and early characterisation of anomalies	High specificity allows localisation and characterisation of tumours as benign or malignant	Reduced treatment costs through efficient monitoring	Personalised treatment
		Reduced operational costs	Painless and non-invasive procedure
			Not threatening
			Reduced anxiety
			Shorter treatments
Innovation 2: Catheter-based cryoablation to treat atrial fibrillation			
Problem	Problem	Problem	Problem
Estimates of morbidity and mortality	Irreversible effects or damages caused by heat-based ablation	N/A	*For patients*
Description of the risks and complications associated to A-Fib			Patients feel pain when RF energy is applied, or face a life-long drug treatment
Description of the risks and complications associated to heat-based ablation			
Solution	Solution	Solution	Solution
Effectiveness and safety of cryoablation	Adjustable time and temperature	Procedure time comparable to the time needed to perform an RF procedure	Quick and easy to set up and use
Reduced risks of serious complications	Reversibility of action on tissue and stability of the catheter		*For patients*
	Completeness of the suite (console, catheters, data, etc.)		Personalised treatment
	Real-time feedback		Low-risk procedure, with little or no discomfort and pain
			Providing a permanent cure, avoiding medication and leading a more active life
Innovation 3: Decision-support software to prevent birth-related injuries			
Problem	Problem	Problem	Problem
Estimates of morbidity	N/A	OB specialty is highly litigated, service delivery is chaotic and malpractice insurance premiums are rising	Failure or delay to recognize, communicate or intervene appropriately
Lack of data identifying best practices and ambiguity in clinical practice guidelines			Ineffective communication within multi-disciplinary teams

Table 1 continued

Clinical dimension	Technical dimension	Structural dimension	Human dimension
Solution	Solution	Solution	Solution
Improved and standardized medical risk assessment reducing subjectivity and uncertainty	Real-time assessment of labour progress and feedback	Detection rates translate into significant savings for hospitals or insurers	Simplified staff training, high team acceptance and usage of the system
Improved detection rate with a relatively small increase in the rate of c-section	Ease of installation and interoperability	Improved team performance and satisfaction	Improved nurse-patient interaction
For women	Modular architecture	Monitoring of several patients at once	Reduced stress and improved physician-nurse cooperation and communication
Alarms that notify caregivers so they may quickly take action	System performance	Improved accuracy and completeness of documentation	*For women*
Improving caregivers' decisions and showing them how successful their actions are	Consistency, completeness and accuracy of individual and institutional databases	Remote accessibility (enable consultation from, or assistance to a colleague)	Involvement in care decisions
		Leverage of current IT investments	Improved communication and time spent with caregivers
			Personalized treatment and sense of security
Innovation 4: Home monitoring for chronic care patients			
Problem	Problem	Problem	Problem
Description of the burden of chronically ill patients (fatigue, lack of energy, limitation in daily living)	N/A	Under detection of changes in health status leading to hospitalisations and ER visits	Patients experience anxiety
Underused strategies to better manage one's chronic illness (diet, exercise, treatment compliance)			
Solution	Solution	Solution	Solution
Early detection of changes in health status	Productive paperless environment	Flexible clinical protocols (can be tailored to meet local needs)	*For patients*
Proactive clinical interventions by healthcare providers	Real-time information	Standardization of care across care teams	Being in the comfort of one's home
Empowered and compliant patients		Continuity of care resulting in improved patient outcomes	Learning to understand and manage one's chronic disease through dynamic questioning and educational messages
		Reduce hospitalisations, ER visits and home care visits	Security of knowing that a case manager is monitoring one's vital signs, medication dosage, and other health related concerns
		More effective use of human resources	
Innovation 5: Computer-assisted navigation system to support minimally invasive orthopaedic surgery			
Problem	Problem	Problem	Problem
Shorter incisions reduce the ability to position implants	N/A	Leg length discrepancy is a cause of malpractice suits	Surgeons need to further their MIS practice
Surgeons face increased clinical expectations			
Risks associated to poor positioning			

Table 1 continued

Clinical dimension	Technical dimension	Structural dimension	Human dimension
Solution	Solution	Solution	Solution
Improved surgeon visualisation	Simplicity and quality of the positioning system	Improved surgical process through real-time data and completion of surgeries with little added time	Option between manual probing and use of a drill according to the surgeon's preference
Reduced complications	Reduced number of incisions for bone references	Compatibility with several knee implants	*For patients*
Improved patient outcomes and increased implant longevity	Compact and easily transportable	Efficiency and cost savings for hospitals, insurers and the health system	Reduced patients' recovery time
	Modularity, flexibility and adaptability		Restoration of normal mobility and improvement to one's quality of life
	Reduced number of particles ejected into the bloodstream		Reduced risks of post-operative pain

The value of five innovations according to their manufacturers' websites

We first examine how manufacturers' websites articulate a value proposition given the clinical, technical, structural and human problems they identify as being solvable by each of the five innovations. We then summarise the range of valuable socio-technical goals and features that underpin the framing strategies of the five manufacturers and that explain, from their perspective, how health innovation brings value to health care.

What is the problem? And what is the solution?

Innovation 1: Optical molecular imaging device for breast cancer diagnosis and characterisation

Innovation 1 is a new imaging device that can be used to support clinical research and has the potential to support treatment follow-up. To emphasise the clinical problem addressed by this innovation, the manufacturer website highlights the incidence and mortality rate of breast cancer in Canada (see Table 1). From a technical perspective, while it is clearly stated that Innovation 1 is approved only as an *adjunct* to mammography, the website nevertheless seeks to demonstrate the problems associated with this existing imaging modality. In order to do so, the website emphasises the innovation's clinical, technical and structural problems. First, it is stated that mammography is not sufficiently specific and there is a vulnerable clinical population that is currently not well served by mammography: "According to a study in the *New England Journal of Medicine*, women with dense breast tissue are far more likely to develop breast cancer. Mammography has a limited ability to penetrate dense breast tissue." (Extracted from the website and where no scientific reference is provided.) The second technical argument used is that mammography cannot help clinicians distinguish malignant from benign tumours. This technical shortcoming is then *translated* into structural terms, that is, the auxiliary costs associated with mammography:

> [Innovation 1] could, therefore, have the potential to reduce the number of painful and often unnecessary biopsies currently performed following suspicious mammograms. These biopsies cost the American health care system U.S. $1 billion a year and are an important source of expenditure in the Canadian and European health care systems, too.

The solution offered by Innovation 1 embraces the current dominant discourse around cancer diagnosis and treatment: the earlier cancer is diagnosed, the more likely it will be cured. The manufacturer also defines itself as

Table 2 A summary of how manufacturers' websites define the problem addressed and the solution provided by their innovation

Innovation	Problem	Solution
Innovation 1: Optical molecular imaging device for breast cancer diagnosis and characterisation	A technological gap *Mammography is limited*	Prevention –supporting early diagnosis *Providing early breast cancer diagnostic and eventually monitoring treatment more safely*
Innovation 2: Catheter-based cryoablation to treat atrial fibrillation	A technological gap *Existing treatments for atrial fibrillation are limited*	Treatment and prevention of conditions that become more severe over time *Providing an improved technology that may cure a widespread health problem*
Innovation 3: Decision-support software to prevent birth-related injuries	A new technological response to a problem framed through clinical and user dimensions *Obstetrical practice is chaotic and too subjective*	Prevention of rare but costly obstetrical complications *Predicting objectively birth-related injuries*
Innovation 4: Home monitoring for chronic care patients	A new technological response to a vaguely defined problem *Chronic illness could be better managed at home*	Monitoring –supporting early diagnosis and preventing the use of costly resources *Improving the management of chronically ill patients through home monitoring and patient empowerment*
Innovation 5: Computer-assisted navigation system to support minimally invasive (MIS) orthopaedic surgery	An add-on that could solve the problems created by an existing technology *Orthopaedic MIS is not optimal*	Incremental improvement of MIS that reduce current complications *Increasing accuracy in orthopaedic surgical practice and reducing complications*

"being part of the larger community of researchers," who seek to find a cure for cancer through the development of more sensitive diagnostic tools. According to the website, Innovation 1 represents a more promising technological response not only for early diagnosis but also, and more importantly, for monitoring treatment outcomes. Clinically speaking, the optical molecular imaging device can be used to image patients with radio-dense breast tissue (that is, younger women) and it enables the characterisation of lesions. From a technical standpoint, Innovation 1 is presented as a safer technology because it: "emits no ionizing radiation, so any number of scans can be done without risk. This compares favourably with mammography, the use of which must be strictly limited." The structural benefits are "increased productivity," reduced number of "unnecessary biopsies" and reduced treatment costs due to more efficient monitoring. Finally, Innovation 1 addresses human dimensions as its use, it is argued, enables personalised treatment and thus results in less pain, suffering and anxiety for a significant number of women.

Innovation 2: Catheter-based cryoablation to treat atrial fibrillation

Cryoablation is a procedure that uses extreme cold to eliminate abnormal electrical conduction in heart tissue. It addresses a number of different heart problems, but especially atrial fibrillation (A-Fib). The high incidence of atrial fibrillation is an important clinical argument in favour of developing a technological response that can outperform existing treatments, which either rely on ablation using heat (instead of cold) through radiofrequency (RF) energy or a life-long pharmaceutical treatment. The website appears to be geared at educating an attentive public and conveying the importance of prevention:

> While the condition isn't considered life-threatening, people with A-Fib are 5 to 7 times more likely to form blood clots and suffer a stroke. […] Atrial fibrillation is also associated with chronic fatigue and heart failure—where the heart is unable to pump enough blood to the other organs. Fortunately, these risks can be reduced dramatically if they are monitored and treated.

In short, the key problem is preventing heart conditions that become more severe over time if an arrhythmia is left untreated or is sub-optimally treated. From a technical standpoint, cryoablation is presented as an "innovative technique", while its key competitor, a catheter-based procedure using RF energy, embodies the "traditional method." As was the case for Innovation 1, the clinical, technical and structural problems emphasised on the

Table 3 A summary of the valuable socio-technical goals and features mobilised by five manufacturers to define the value health innovation brings to health care

Clinical dimension Impact on clinical activities and outcomes	Technical dimension Technical assets and comparison with technological alternatives	Structural dimension Impact on work processes and health care structures	Human dimension Response to clinicians' and patients' values, expectations and constraints
Reducing risks and complications associated to current practices (2, 3, 4, 5)	Real-time feedback (2, 3, 4, 5)	Reducing costs for hospitals, insurers and health systems (1, 3, 4, 5)	Personalised treatment (1, 2, 3, 4)
Effectiveness, safety and patient outcomes (2, 3, 4, 5)	Precision, performance and simplicity (1, 2, 3, 5)	Monitoring (1, 3, 4)	Reducing invasiveness and painfulness (1, 2, 5)
Precision, early diagnosis, improved detection rate (1, 3, 4)	Modularity, flexibility, interoperability and adaptability (2, 3, 4, 5)	Productivity/effective use of human resources (1, 3, 4)	Reducing patient anxiety/ providing a sense of security (1, 3, 4)
Objectivity, predictability, improved clinical decision-making (3, 4, 5)	Providing more biomedical information (1, 3)	Compatibility with existing products (3, 4, 5)	Patient's quality of life (2, 4, 5)
Proactive care/responsiveness (3, 4, 5)	Technical improvements reducing side effects (1, 5)	No impact on procedure time (2, 5)	User-friendly implementation and staff training (2, 3, 4)
Support research (1)	Completeness of the solution (2)	Standardization of care (3, 4)	Reducing treatment/recovery time (1, 5)
Reach a greater number of patients (1)	Accuracy of databases (3)	Team performance/satisfaction (3, 4)	Patient empowerment/involvement in care decisions (3, 4)
Feedback to caregivers (3)	Paperless environment (4)	Accuracy of documentation (3, 4)	Physician-nurse cooperation and communication (3, 4)
Compliant patients (4)	Transportability (5)	Remote accessibility (3, 4)	Nurse-patient communication (3, 4)
		Continuity of care (3, 4)	Accommodate providers' preferences (4, 5)
		Reducing use of auxiliary products (1)	Reducing medication intake (2)
		Repeatable procedure (1)	Receiving care at home (4)

The number in parentheses indicates the innovation(s) to which each item is associated

website are mainly the shortcomings of the alternative technique. For example, RF treatment may cause clinical problems that would not occur with cryoablation: "Heat burns and chars the ablated tissue. This tissue disruption can result in clot formation called thrombus in medical terms. The thrombus can dislodge and migrate into a blood vessel which can lead to stroke."

The solution Innovation 2 provides is mostly established on the basis of clinical and technical factors. From a clinical perspective, cryoablation is presented as an effective and safe procedure for treating arrhythmias, one that limits complications. With regards to the technical dimension, Innovation 2 offers physicians "real-time feedback," "multiple catheter options" and can "prevent accidental damage to critical structures." The website argues that because the catheter tip firmly attaches to tissue during cryoablation, the intervention is more precise and so the risks of tissue damage are lessened. This feature, called cryoadhesion, is an important technical advantage because the heart is in constant movement during the procedure. Another important technical asset is the reversibility of cryoablation, which:

> allows the electrophysiologist to slightly freeze tissue to test whether it is responsible for conducting an arrhythmia. Heat-based therapies don't allow that—once the tissue is burned, it stays burned. By contrast, cryoablation allows the electrophysiologist to re-warm frozen tissue (that is not responsible for the arrhythmia) and restore its normal electrical function.

From a structural perspective, only the time required to perform cryoablation versus RF is examined, with the conclusion that Innovation 2 represents a substitute that will not negatively impact on the delivery process. Most claims regarding the human dimension invoked on the website refer to the patient. Because of its reversibility, cryoablation can be customised to patient needs. It is also noted that "when applying RF energy, some patients feel pain which has not been reported to date with Cryotherapy." Further, patients will not have to "take medication for the rest of their lives" and will be able to resume an active life following the treatment.

Innovation 3: Decision-support software to prevent birth-related injuries

Innovation 3 consists of a set of decision-support tools for obstetrical risk management. Its goal is to prevent birth-related injuries such as shoulder dystocia, and to better manage prolonged labour and abnormal foetal heart rates. While the manufacturer's website indicates the incidence of birth-related injuries (shoulder dystocia "occurs in about 0.4 to 3 vaginal births per 1000"), the key issues it emphasises are both clinical and structural in nature: birth-related injuries are presented as being *predictable* and therefore preventable, as well as extremely costly from a liability perspective. Nevertheless, the website strongly suggests that human dimensions are at the root of the problem: "The main contributors to preventable birth-related injuries are failure or delay to recognize, anticipate, communicate or intervene." This failure is then explained by a set of clinical, structural and human dimensions that all dovetail in practice. The website notes that current clinical guidelines are vague and at times unhelpful, and "the standard of care is open to a wide variation in interpretation."[7] From a structural perspective, obstetrical practices are said to be highly chaotic and hard to manage: "Labour and delivery is a crisis waiting to happen—quiet times can be followed by an abundance of patients seeking immediate attention." The incidence of birth-related injuries becomes even more problematic when their impact is translated into structural dimensions: shoulder dystocia "represents 17% of lawsuits in obstetrics" while "medical liability payouts for a baby with subsequent disability average around $500,000." Human dimensions such as "stress," "fatigue," "wishful thinking" and "impaired judgment" are mentioned, as is ineffective "communication within multi-disciplinary teams."

Innovation 3 was thus designed to provide a "standardised" method for measuring labour progress that would reduce the "subjectivity" and "uncertainty" associated with obstetrical practice by "objectively" predicting potential birth-related injuries. In essence, what Innovation 3 is trying to do is *eliminate* human dimensions that have previously been defined as highly problematic. Interestingly, the website presents several clinical arguments directly addressed to women, such as "In the rare event that your baby's heart rate falls outside the normal range, an alarm will sound, notifying your caregivers immediately so that they may quickly take action." To health care providers and managers, several technical arguments are presented that centre on real-time feedback, flexibility and inter-operability. For example, the software platform and its accompanying tools are presented as being compatible with other equipment found in an obstetrical unit. Furthermore, the innovation is positioned as a sustainable option: customers will be able to "seamlessly upgrade and tailor the system as the department grows or its needs

[7] Here, two arguments invoking scientific authority are brought to the fore: 1) "There's little data to show which manoeuvre is more effective at alleviating shoulder dystocia without injury;" and 2) "Existing guidelines recommend consideration of elective caesarean when estimated foetal weight is greater than 5,000 g, or over 4,500 g in the presence of maternal diabetes. … However, the average foetal weight of babies experiencing shoulder dystocia with injury is around 4,000 g".

change." A number of structural benefits are linked to the system's architecture: it can be used in various settings and thus is "accessible from the physician's office or from the hospital." The website suggests that the accuracy and "completeness" of documentation will be improved. More salient is the notion that by reducing the risks of birth-related injuries, Innovation 3 also reduces liability costs. While the innovation is aimed at eliminating the "negative" human factors associated with current obstetrical practice, the website argues that the innovation will also improve other human dimensions; for example, thanks to visual aids that clearly show labour progress, the innovation improves communication within multi-disciplinary teams and between clinicians and patients. By addressing women directly, the website seeks to convey a sense of security, while simultaneously reinforcing the centrality of medical authority:

> Your caregivers can now spend more time directly caring for you. Your caregivers see how well you and your baby are doing at a glance wherever they are. Through clear visual displays you will easily understand your progress and *feel more confident in consenting* to any actions your caregivers recommend to improve your progress and ensure both the safety of yourself and your baby [our emphasis].

Innovation 4: Home monitoring for chronic care patients

Innovation 4 is aimed at "promoting continuity of care to chronically ill patients" by enabling them to remain at home while a case manager monitors their health status from a distance. Like with Innovation 3, the website for Innovation 4 does not mention any technological competitor. Nor does the website give very much information on the underlying clinical problem being addressed, other than that patients with heart failure, hypertension, diabetes and those preparing for heart surgery would benefit from closer clinical monitoring. The key problems that Innovation 4's website highlight relate to changes in health status that would be under detected by health professionals, and to user issues, namely patients who feel "anxiety" and would benefit from care received in the "least restrictive environment." Overall, the website does not offer much information to help its potential customers better understand why home monitoring is needed; rather, the content on the website more or less assumes that everyone agrees that home care is better than hospital care, and that chronic illnesses can be managed effectively through home monitoring.

Without providing any concrete evidence, the website adopts a concise, assertive tone to describe the clinical benefits of its solution: "Early detection of changes in health status enables the healthcare professional to provide proactive clinical interventions," and home telemonitoring is "a proven effective tool for providing quality care to patients with cardiac diseases." The website also suggests that more compliant patients would translate into better clinical outcomes. Given the high profile that information technology has acquired in health care systems over the past decades, it is surprising how very few technical arguments are provided on the website, aside from brief reference to a "paperless" environment that carries "real-time information." The website mentions several structural factors, such as the fact that health care organisations can develop or adapt their own health care protocols and that potentially deteriorating health care conditions that would otherwise lead to emergency room visits and hospitalisations will be avoided. It is also suggested that Innovation 4 improves continuity of care and leads to a better use of human resources through the standardisation of care and the development of a common language among health care providers. Under the human dimension category, Innovation 4 is presented as a means to support, from a distance, the work of case managers and to *empower* patients, enabling the latter to ask questions on an ongoing basis, learn more about their illness and how to better manage it: "in the comfort of their own homes, patients have the security of knowing that a case manager is monitoring their vital signs and other health related concerns." Implicit is the assumption that a case manager is always in some way connected through the monitoring system and able to respond.

Innovation 5: Computer-assisted navigation system to support minimally invasive orthopaedic surgery

Innovation 5 is interesting because it contrasts sharply with the other four innovations by seeking to fix problems associated with a newly established practice: minimally invasive surgery (MIS). Surgeons are presented as "continually [facing] increased clinical expectations" and the manufacturer's website clearly emphasises the need to improve "conventional arthroplasty." One key clinical problem is related to "positioning," which is presented as problematic, due in part to the advent of MIS, where "shorter incisions limit the visual access available to precisely position implant components." Clinical risks are mentioned to justify navigation as a legitimate technological add-on: "[Better positioning] can help avoid long-term neurological deficits, reduce incidents of implant loosening and avoid reoperations." Structural factors, like with Innovation 3, refer to litigation resulting from bad surgical outcomes: "leg length discrepancy is one of the most common causes of orthopaedics malpractice suits." Human dimensions are hardly addressed: surgeons are presented as furthering "their art with minimally invasive (MIS)

procedures to speed the return of patients to their normal activity." Innovation 5's website argues that current orthopaedic surgical practices are insufficiently precise and patient outcomes sub-optimal yet does not give a detailed explanation for why this might be the case (in contrast with Innovation 3).

The goal of Innovation 5 is "to assist orthopaedic surgeons to increase accuracy in hip, knee and spine implant surgery." Its value is mostly framed in terms of its ability to improve visualisation for the surgeon and most of its key clinical benefits are enmeshed in its technical assets. For instance, the website states the following about the navigation system: "[It] does not require a conventional intramedullary alignment rod and so, by minimizing compression of the femoral bone marrow, can help reduce the number of particles ejected into the bloodstream. These particles might otherwise contribute to the occurrence of embolisms."

Compared to the other four manufacturer websites, the website of Innovation 5 discusses in much greater detail the technical features associated with the innovation design, drawing attention to its simplicity, modularity, flexibility and transportability. The structural benefits include improving surgical processes with little added time and providing choices to surgery departments; Innovation 5's compatibility with other types of implants does not limit "the hospital's use of other implants." Further, the innovation's benefits would also translate into "cost savings for hospitals, insurers and the health system as a whole," because the system can contribute to a reduction in hospitalisations: "Costs were lowered because of a 75% drop in hip readmission rates and a 4% increase in the number of patients discharged to home." Finally, human dimensions are mentioned: besides its ability to accommodate surgeons' preferences, Innovation 5 improves quality of life for patients whose normal mobility is being restored and it reduces "premature implant wear" and "residual pain and short-term revision surgery."

Valuable socio-technical goals and features that underpin manufacturers' framing strategies

The way in which a manufacturer defines the problem at hand is not inconsequential because it brings to the fore the normative socio-technical goals and features the innovation embodies and how it is expected to improve current approaches. As summarised in Table 2, for two innovations (1 and 2), the framing of their value suggests a technological gap—the existing alternatives are limited—and promises a *technologically superior* response. The value of both Innovations 3 and 4 lies in a *new* technological response to apparently unmet needs: the website of Innovation 3 emphasises the problem through clinical and human issues that can be addressed by increasing objectivity in obstetrical risk management; the website of Innovation 4 provides a vague description of the challenges in chronic illness management that nonetheless can be improved through remote monitoring and patient empowerment. Finally, Innovation 5 is posited as an *add-on* that can address the inaccuracy of an existing technology, thereby improving current outcomes. It is worth noting that in tune with contemporary discourse about health, for three innovations (1, 3, 4), the solution resides in *prevention*—supporting early diagnosis, monitoring and preventing more severe conditions. Even for Innovation 2, which is a therapeutic intervention, its website delivers a largely prevention-oriented message.

When we examine the manufacturers' value propositions across the five cases, we can summarise their claims into a set of general valuable socio-technical goals and features (see Table 3). The clinical dimension category contains claims that are easily associated to modern medicine, which seeks to increase providers' objectivity, capacity to assess and predict risks and intervene earlier. However, perfection in health care can never be achieved, and the pursuit of clinical improvements may continue indefinitely. The same applies to the technical dimension, where *more* technological features that generate *more* information are posited as necessarily *better* and valuable in themselves. This portraying of technical assets is compatible with the ideology of technological progress, which routinely casts "breakthroughs" as something imminent, irreversible and inherently positive or beneficial. Even though Innovation 5 was designed to fix the problems created by a recent innovation (MIS), the framing of its value does not, paradoxically, deviate from this ideology. Several of the structural claims invoked focus on the assertion that clinicians and health care organisations would be able to accomplish *more,* perform *better* and work *more efficiently* (individually or through collaboration). Finally, the human dimension category contains arguments intended for both providers and patients, alluding to the idea that the latter can be empowered and more involved in care decisions. While one website seeks to "educate" potential patients by providing content adapted to a non-expert audience (Innovation 2), another website (Innovation 3) frames its innovation's benefits by "talking" directly to patients in a reassuring yet paternalistic tone.

Table 3 shows that a specific range of valuable socio-technical goals and features are evoked, all of which reinforce a modern medical discourse wherein social and technological changes influence each other and are necessarily desirable. When examined individually, each innovation seems to be valuable — according to the arguments presented by its promoters — but if they were to be

considered together from the perspective of third-party payers, establishing their *comparative* value would become a necessity. For instance, Innovation 4 is probably the one among our five cases whose value proposition is the most closely aligned to current health care system needs and challenges. In contrast, the other four innovations reflect a gradual process of clinical specialisation that first builds on a techno-scientific discovery and then develops an application to help improve clinical practice in one specific area within a medical specialty. In fact, when each innovation is taken in isolation, it becomes clear that both clinical and technical claims are mutually fuelling each other. That is, incremental improvements will always be possible, leaving aside the question of the threshold at which certain "benefits" may not prove sufficiently valuable to warrant the associated "costs." If these innovations had been designed to respond to existing problems as defined from a *health care system perspective* instead of focusing on what a given innovation may deliver, it is very likely that other value propositions (taking form around other solutions) would have emerged. Moreover, manufacturers' websites ignore the tensions that may be caused by juxtaposing multiple claims, for instance, clinical and structural claims that contradict one another (e.g., earlier detection of diseases and screening of more patients vs. efficiency and cost-reduction).[8] Hence, while we recognise that the trade-offs associated with each innovation remain policy context-dependant, our analysis helps uncover the persuasive web-based rhetorical means that each manufacturer articulates and puts into circulation in the health policy arena.

Medical devices' corporate value proposition on the web: implications from a health care system perspective

Following Saukko et al. (2010), we paid particular attention to the framing process employed by medical devices manufacturers, via their corporate websites, to selectively disclose issues, facts and arguments to their various audiences. This process is intentional in that the websites are designed so as to direct visitors to certain types of information (i.e., specific tabs entitled "for clinicians" or "for patients"). The language being used also changes in function of certain audiences (i.e., experiential/emotional with patients and scientific with physicians). Overall, the five medical device manufacturers promote their innovations by emphasising their putative ability to augment clinical activities, to outperform competitors, to improve organisational work processes and to respond to human expectations and values. Although our study was not designed to examine whether such claims do, in practice, shape how users and stakeholders think and make decisions about medical devices, it nevertheless suggests that manufacturers' framing strategies deserve to be carefully considered by both scholars and policymakers.

Because research that summarises in plain language the financial and clinical trade-offs faced by physicians and patients (at the clinical level) or by third-party payers (at the policy level) is extremely rare, these stakeholders may find it difficult to obtain impartial or balanced information about health innovations. Studies have also shown that hospital-based physicians, nurses and biomedical engineers rely to a large extent on information provided by manufacturers in order to prepare and submit budget requests for acquisition of medical technologies (Faulkner and Kent 2001). Acknowledging that the industry gives financial support to various interest groups (who are not always transparent about their funders) who then lobby policymakers (Hemminki et al. 2010; Light et al. 2003), we believe that the on-line framing strategies we observed may perform as powerful rhetorical tools for those stakeholders who seek to influence the decisions of purchasers.

Our summary table (Table 3) indicates that manufacturers define the value of their health innovation by mobilising a considerable array of interrelated valuable goals and features that invoke broad socially shared constructs. Not surprisingly, the websites do not support the vast majority of their assertions with what health services researchers would define as convincing evidence. However, keeping in mind that the Canadian medical device industry is targeting domestic as well European and American markets, the goals and features invoked by the five manufacturers appear congruent, at least on the surface, with the expectations of large segments of industrialized countries (Giacomini et al. 2004, p.18). Gaining ever more control over diagnosis and treatment processes, preventing illnesses, increasing the role that patients play in health care and improving their quality of life are all part of a discourse in which modern health care values are smoothly reconciled and recombined (Boenink 2010). Nevertheless, this rhetoric mobilises values without clarifying in what ways they are sustained in practice. Priester (1992, p. 18) argues that making explicit the values according to which priorities in health care systems are set can help stakeholders "reach agreement on what should reasonably get out of the system" and make clear the trade-offs facing policymakers. An explicit framework of values

[8] As suggested by one reviewer, substantial ethical issues may reside in the tensions between the four categories we analyzed. Although space precludes us from exploring these tensions, we certainly recognize that such tensions could be the source of significant ethical debates. For instance, tensions between the clinical and the structural dimensions of an innovation may raise concerns about the appropriate roles and responsibilities of individual physicians and those of an organized, publicly funded health care system.

would, according to Priester, enable the public "to hold policymakers accountable, so that policies promote and do not detract from underlying values" (p. 86). This would require not only greater clarity regarding the values and valuable goals that are considered important from a health care system perspective, but perhaps more importantly, necessitate solid critiques of how certain kinds of medical devices bring a more (or less) valuable response to health care needs when compared to others. Without such a framework, assessment and adoption of health technology on a case per case basis will continue and the industry's promotional strategies will simply exacerbate current policy challenges.

In a context where both private and public health care systems are struggling with cost escalation, and where health technology is identified as a key cost-driver, it is not surprising that manufacturers' value proposition includes costs savings. While only two manufacturers (Innovations 3 and 5) specifically mention litigation costs, all invoke the *common understanding* that health care costs can be reduced through increased prevention, early diagnosis and intervention, better coordination, enhanced continuity of care and so forth. These arguments may be appealing and eventually convincing to a general audience. For instance, in a survey and focus groups conducted with American voters in 2006 and 2007, Lake et al. (2008, p. 695) found that although participants' "understanding of cost drivers is usually muddled (far overestimating the importance of malpractice suits, for example), the desire to get costs under control is the most powerful impetus for change." Another valuable goal that was mentioned in all five websites was risk reduction. The websites tended to nurture a sense of security with regards to their innovation by evoking the need to address patients' comfort, anxiety, pain and safety, and to help physicians and nurses reduce risks and avoidable complications. Again, this message fits well with modern health care policy reforms: "the discourse of science that gathered around risk assessment proved irresistible to regulators and modernist managers of every stripe, all of whom found risk assessment to be an invaluable tool" (Jasanoff 2005, p. 266). The websites we examined may thus contribute to a "collective muddling" regarding the safety and costs of medical innovations.

It is also helpful to reflect on issues that were omitted in the framing process and how such frames may operate, more broadly, in the health policy arena. While most websites tended to highlight the clinical and technical problems, only one (Innovation 3) offered a more detailed analysis of the limitations of existing clinical practices. All of the websites provided sweeping promises with respect to the structural value of their solution, but none of them explained how, in practice, the expected benefits would be generated. For instance, for four innovations (1, 3, 4, 5), there is a significant emphasis on the need to access immediate, real-time information, which is presumed to automatically improve clinical practice. As underscored by Boenink (2010, p. 17), the idea of "permanent monitoring" is pervasive in biomedical innovations, even though such tools also require, in parallel, that clinicians and patients learn to deal with the uncertainty, ambiguity and unreliability of the information generated. Manufacturers' framing strategies ignore what Woolf and Johnson (2005, p. 545) refer to as health care "fidelity," that is, the extent to which the health care system can provide "patients with the precise interventions they need, delivered properly, precisely when they need them." And this understanding of what constitutes valuable health care—which distinguishes efficacy from effectiveness—is exactly what third-party payers (governments and medical insurers) need to rely on in order to set meaningful priorities among competing health technologies.

While it is the role of payers to rigorously weigh the available evidence and make decisions that are independent from the industry's promotional strategies, manufacturers' rhetorical tools, which contain strong ethical appeals, may prove difficult to counter (Brown 2003).[9] Even though many of the risks and benefits related to the adoption and use of a new technology are often underestimated or unknown at an early stage of commercialisation, when persuasive social and technological imperatives operate together, they tend over time to legitimise technology-related policy (Jasanoff 2005). For instance, when a less invasive prenatal test becomes available and builds on a culture where early detection is seen as highly desirable, it becomes difficult not to approve the innovation's dissemination despite the ethical and social issues it raises (Lehoux et al. 2009). Furthermore, one should recognise that evidence about the outcomes of health technologies is continually evolving and is often lagging behind the process of their diffusion (Faulkner 2008). As evoked through our findings, if the value proposition of a given innovation was scrutinized earlier in its development process, the way in which it does respond or not to health care systems needs and challenges could be examined more constructively. From a public policy perspective, articulating value propositions that are more closely aligned to significant health care needs would help improve R&D processes. Within this perspective, empirical ethics scholars could bring a useful contribution by examining which of the valuable goals and features we identified may prove more

[9] Whether manufacturers' rhetoric regarding costs and risks reduction is convincing or not to a policymaking audience remains an open question. The real promises of innovations might simply be disregarded due to perceived uncritical marketing or even unsubstantiated hype (Brown 2003; Williams-Jones and Corrigan 2003).

meaningful than others and which are likely to be sustained in practice.

Because the framing strategies we observed on the websites tend to be reproduced in a diverse range of promotional documents, marketing tools and scientific events (Saukko et al. 2010), they may contribute, over the long run, to stabilising judgements about the value of a given health innovation. This may happen because manufacturer's websites deploy normative lenses that not only resonate with the values and expectations of several "customers" (including clinicians, patients, medical insurers and hospital managers), but also enable each of these groups to *see* how valuable a given health innovation might be for them. Further research could thus explore the extent to which manufacturers' rhetorical tools are influencing, in practice, how each stakeholder envisions the desirability of a given health innovation. Are on-line marketing strategies more persuasive than other (face-to-face) marketing strategies? Are ethical appeals more convincing to certain groups? And are they more persuasive than those established on scientific evidence? Examining such questions would generate a better understanding of how stakeholders' judgements about the desirability of medical innovation are forged.

Conclusion

Private and public health care systems across the developed world are actively seeking ways to make increasingly complex resource allocation decisions about health technologies. This is happening in a context where the general public and specific interest groups are increasingly active and sophisticated in using the media to put pressure on policymakers (Jasanoff 2005; Light et al. 2003), and where the pharmaceutical industry is strategically reinforcing its promotional activities through the production of particular types of evidence (Gagnon 2009). Because not much is known about the medical equipment industry's promotional strategies, our study sought to shed light on the way that manufacturers of medical devices describe the value proposition of their innovation, and what they think matters to their users and stakeholders.

As our analysis suggests, manufacturers do not simply characterise value as something to be found in the technology itself; rather, value is framed as embedded in the health care activities that the technology helps bring about, referencing larger sets of pervasive and implicit social values. Values generally belong to repertoires that are incommensurable (e.g., aesthetics, legal, professional, moral, civic) since they refer to moral goods that can hardly be "traded" one against another. So by making more explicit how the four dimensions of a technology's value proposition build on one another, we have shown how some valuable goals can be "translated" into other repertoires (i.e., lower clinical risks translate into lower litigation costs) (Boltanski and Thévenot 1991). This phenomenon may contribute to render framing strategies even more persuasive because the benefits that a given innovation brings to one stakeholder builds upon and comes with benefits for another. This observation is not only compatible with the recognition that value creation proceeds from a synchronic and interactive process to which various stakeholders contribute (Ramirez 1999), but it also sheds light on the continual and progressive process that characterises the development and institutionalisation of health innovations. While the promises that relate to the clinical and technical value of medical devices are in theory unlimited, both are often considered highly desirable socially.

Our study also showed that the valuable socio-technical goals and features that manufacturers invoke are, at first glance, in tune with the challenges of modern health care systems. However, the reference to these values is clearly more rhetorical than demonstrative; all of the manufacturers that we studied used the notions of cost savings and risk reduction rather loosely. Referring to values that resonate well with a large segment of the population is a common marketing strategy. But this observation should not be dismissed too quickly. Given the increasing challenges faced by policymakers when seeking to regulate the biomedical industry's marketing strategies, the web-based tools we examined in this paper need to be considered with caution. They are likely to be more powerful than they seem exactly because they tend to be "normalised" in the daily practices of those who are exposed frequently to them. For instance, studies indicate that even though most physicians do not believe that pharmaceutical marketing strategies (including the sponsoring of continuous medical education) influence their clinical judgment, such strategies clearly affect drug prescription patterns (Gagnon 2009). A similar effect may arise with the medical device manufacturers' websites, especially because their digital nature makes them easily reproducible, transformable, usable and therefore apparently benign. Finally, given the extremely competitive market environment in which medical device manufacturers operate, our study demonstrates how manufacturers' websites can bolster physician and patient expectations that can then be easily used to put pressure on third-party payers. Establishing sound collective health care priorities among competing technologies will thus require solid critiques of how certain kinds of medical devices may bring a more valuable response to health care needs when compared to others.

Acknowledgments This research was funded by an operating grant from the Canadian Institutes of Health Research (CIHR; #MOP-

89776). P. Lehoux holds a Canada Research Chair on Health Innovations (2010–2015). Fiona Miller holds a New Investigator Award from the Institute of Health Services and Policy Research of the Canadian Institutes of Health Research. Our research group infrastructure is supported by the *Fonds de la recherche en santé du Québec* (FRSQ).

References

Akrich, M. 1995. User representations: Practices, methods and sociology. In *Managing technology in society: The approach of constructive technology assessment*, ed. A. Rip, T.J. Misa, and J. Schot, 205–224. London: Pinter.

Boenink, M. 2010. Molecular medicine and concepts of disease: the ethical value of a conceptual analysis of emerging biomedical technologies. *Medicine, Health Care and Philosophy* 13: 11–23.

Boltanski, L., and L. Thévenot. 1991. *De la justification. Les économies de la grandeur*. Paris: Gallimard.

Brown, N. 2003. Hope against hype—accountability in biopasts, presents and futures. *Science Studies* 162: 3–21.

Brown, N., and A. Webster. 2004. *New medical technologies and society: Reordering life*. Cambridge: Polity Press.

Chesbrough, H., and R.S. Rosenbloom. 2002. The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change* 11(3): 529–555.

de Chernatony, L., F. Harris, and F.D. Riley. 2000. Added value: its nature, roles and sustainability. *European Journal of Marketing* 34(1/2): 39–56.

Einsiedel, E.F. 2006. Introduction: Making sense of emerging technologies. In: *First Impressions: Understanding Public Views on Emerging Technologies*. GenomePrairie GE3LS Team, University of Calgary.

Evans, B. 1984. *Strained mercy: The economics of Canadian health care*. Toronto, Canada: Butterworths.

Faulkner, A. 2008. *Medical technology into healthcare and society: A sociology of devices, innovation and governance*. Hampshire, UK: Palgrave Macmillan.

Faulkner, A., and J. Kent. 2001. Innovation and regulation in human implant technologies: developing comparative approaches. *Social Science and Medicine* 53(7): 895–913.

Gagnon, M.-A. and J. Lexchin. 2008. The Cost of Pushing Pills: A new estimate of pharmaceutical promotion expenditures in the United States. *PLoS Med* 5(1): e1. doi:10.1371/journal.pmed.0050001.

Gagnon, M.-A. 2009. *The nature of capital in the knowledge-based economy: The case of the global pharmaceutical industry*. York University: PhD in Political Science Dissertation.

Giacomini, M., J. Hurley, I. Gold, P. Smith, and J. Abelson. 2004. The policy analysis of value talk: Lessons from Canadian Health reform. *Health Policy* 67: 15–24.

Grunwald, A. 2004. The normative basis of health technology assessment and the role of ethical expertise. *Poiesis & Praxis* 2: 175–194.

Haimes, E. 2002. What can the social sciences contribute to the study of ethics? Theoretical, empirical and substantive considerations. *Bioethics* 16(2): 89–113.

Häyry, M. 2003. European values in bioethics: Why, what, and how to be used? *Theoretical Medicine* 24: 199–214.

Hemminki, E., H.K. Toiviainen, and L. Vuorenkoski. 2010. Co-operation between patient organisations and the drug industry in Finland. *Social Science and Medicine* 70(8): 1171–1175.

Jasanoff, S. 2005. *Design on Nature: Science and Democracy in Europe and the United States*. Princeton, NJ: Princeton University Press.

Lake, C.C., R.A. Crittendon, and D. Mermin. 2008. Health care in the 2008 election: Engaging the voters. *Health Affairs* 27(3): 693–708.

Lehoux, P. 2006. *The problem of health technology*. Policy implications for modern health care systems. New York: Routledge.

Lehoux, P., J.-L. Denis, M. Rock, S. Tailliez, and M. Hivon. 2009. How do medical specialists appraise three controversial health innovations? Scientific, clinical and social arguments. *Sociology of Health & Illness* 32(1): 1–17.

Light, D.W., R. Castellblanch, P. Arredondo, and D. Socolar. 2003. No exit and the organization of voice in biotechnology and pharmaceuticals. *Journal of Health Politics, Policy and Law* 2(2–3): 473–507.

Molewijk, A.C., A.M. Stiggelbout, W. Otten, H.M. Dupuis, and J. Kievit. 2004. Implicit normativity in evidence-based medicine: A plea for integrated empirical ethics research. *Health Care Analysis* 11: 69–92.

Nelson, G.D. 1995. Medical device industry efforts to increase healthcare value. *The Annals of Thoracic Surgery* 60: 1534–1536.

Normann, R., and R. Ramirez. 1994. *Designing Interactive Strategy: From Value Chain to Value Constellation*. Chichester: John Wiley & Sons.

Porter, M. 1985. *Competitive Strategy*. Techniques for Analysing Industries and Competitors. New York: The Free Press.

Priester, R. 1992. A values framework for health system reform. *Health Affairs* 11(1): 84–107.

Ramirez, R. 1999. Value co-production: intellectual origins and implications for practice and research. *Strategic Management Journal* 20: 49–65.

Saukko, P.M., M. Reed, N. Britten, and S. Hogarth. 2010. Negotiating the boundary between medicine and consumer culture: Online marketing of nutrigenetic tests. *Social Science and Medicine* 70: 744–753.

Smith, E., C. Martin, J. Behrmann, and B. Williams-Jones. 2010. Reproductive tourism in Argentina: accreditation and its implications for consumers and policy makers. *Developing World Bioethics* 10(2): 59–69. (Published Online First: June 8 2009).

Strauss, A., and J. Corbin. 1990. *Basics of Qualitative Research*. Newbury Park: Sage.

Teutsch, S.M., and M.L. Berger. 2005. Misaligned incentives in Americas health: Who's minding the store? *Annals of Family Medicine* 3(6): 485–487.

Vicente, K. 2004. *The Human Factor: Revolutionizing the Way People Live with Technology*. New York: Routledge.

Williams-Jones, B., and O.P. Corrigan. 2003. Rhetoric and hype: Where's the "Ethics" in pharmacogenomics? *American Journal of Pharmacogenomics* 36: 375–383.

Williams-Jones, B. 2006. Be ready against cancer, now: Direct-to-consumer advertising for genetic testing. *New Genetics and Society* 25(1): 89–107.

Woolf, S.H., and R.E. Johnson. 2005. The break-even point: When medical advances are less important than improving the fidelity with which they are delivered. *Annals of Family Medicine* 3(6): 545–552.