

Interactive Communication in Pharmacogenomics Innovations: User-producer interaction from an innovation and science communication perspective

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Abstract

Pharmacogenomics is a quickly evolving field of research that increasingly impacts individuals and society. As some innovations in biotechnology have experienced strong public opposition during the 1990s, interaction between producers and users of these innovations may help in increasing their success in social and economic terms. However, conditions for effective interaction have so far remained under-explored. This paper explores user-producer interactions in pharmacogenomics from an innovation and science communication perspective in the Netherlands. To find possible ways of engaging stakeholders in an early stage of technology development, ie, when science policy is in the making, we present communication activities derived from the field of policy analysis. To articulate motives for two-way public participation in genomics innovation processes, we describe two levels at which pharmacogenomics developments will have an input: 1) at the meso-level of medical practice with already established medical technologies, values and routines, suppliers and health professionals (general practitioners, pharmacists), and 2) at the macro-level of society at large, with established institutions, infrastructures, and broadly shared values and beliefs among citizens in general. Thereby we offer a starting point for optimising decision-making processes in the field of pharmacogenomics innovations, including important aims to be reached, stakeholders to be involved, and some criteria for designing interactive communication activities.

Introduction

Pharmacogenomics is a relatively young and quickly evolving field of research, which promises to release a variety of new innovations in clinical practice and in everyday life. It is beginning to harvest the genetic information available after the completion of the Human Genome Project and convert it into functional innovations, eg, (pharmaco)genetic tests and tailored medicines for (groups of) patients and consumers. Pharmacogenomics is defined here as:

“the study of the variability of the expression of individual genes relevant to disease susceptibility as well as drug response at cellular, tissue, individual or population level. The term is broadly applicable to drug design, discovery, and clinical development”²

It implies genome-wide searches for genes and their products (ie, proteins) involved in (common) diseases and the provision of new targets for therapy. In addition, pharmacogenomics aims to identify genes involved in adverse reactions to drugs. Pharmacogenomics increases the potential for early diagnosis and fine-tuning of

prognoses for diseases of adulthood, eg, cancer, cardiovascular diseases, diabetes and neurodegenerative diseases, eg, Alzheimer's disease. Some companies already provide individuals with their own genotypes and estimated associated risks deduced from clinical association studies.

As some innovations in biotechnology have suffered from strong public opposition during the 1990s, interaction between the producers and users of these innovations has been suggested to be essential in increasing the success of these innovations in social and economic terms.³ User-producer interactions work both ways. Users can gain attention for their (future) needs and have influence on the research and development processes by which these needs may be fulfilled. Producers gain access to the potential creativity and tacit knowledge of users and improve the societal acceptance of (future) innovations. It has been claimed that user involvement also contributes to the democratic content of decision-making on innovation.⁴ However, the interaction process itself often remains a "black box", and conditions for its optimization remain rather unclear.

The influence of users in pharmacogenomics is ambiguous. Producers, within science and the science-based pharmaceutical industry, play a major role in the development of new drugs, and "users" (eg, patients, consumers, general practitioners) cannot be typified as a group of homogeneous mass-consumers. Furthermore, as pharmacogenomics is still an emerging technology in an embryonic phase of its development characterised by high uncertainties and need for flexibility, the Collingridge dilemma applies:⁵ in an early stage of an emerging technology it is difficult for stakeholders to specify their needs, visions, goals and ethical considerations. In later stages, when actors know better how they want to intervene, the options to do so are limited. Therefore it has been argued that users and other stakeholders should be supported in articulating their demands and participating in science and technology policy-making as early as possible.⁶

This paper explores user-producer interaction from an innovation and science communication perspective. To find possible ways of engaging users and other stakeholders in early stage technology development, ie, when science policy is in the making, we present some activities of user-producer interaction derived from the field of policy analysis. The diversity of pharmacogenomics stakeholders and the different contexts in which pharmacogenomics innovations will be used arguably have implications for the manner of user-producer interaction. Therefore two levels are distinguished at which future pharmacogenomics innovations will have an input: the level of medical practice and of society at large, focussing on The Netherlands. The final part of this paper presents some implications for communication strategies in pharmacogenomics.

User producer interaction

An innovation perspective

In innovation studies, the importance of including users in innovation processes has been widely acknowledged.⁷ These studies have shown that intensified user-producer

interaction increases the success of innovations. Presently, innovation processes are considered as dynamic, complex and interactive processes. The linear model of innovation, in which new technologies are transferred from scientists (discovery) to developers and producers (invention and innovation) to consumers (diffusion) in a one-way direction, does not reflect the mechanisms that operate in reality. Actual use of the innovative product during clinical trials is necessary to generate knowledge that is required to improve the product. In other words, innovation is very much a process of “learning by using” and “learning by doing”⁸ Innovations also emerge in close interaction with their (socio-economic) environment. Nelson and Winter⁹ characterized this process as co-evolution with continuous feedback and feed forwards to align the redesign of product characteristics and user requirements. Accordingly, new technologies are developed in a dynamic and complex environment and are shaped in an interactive process in which several actors (users, producers, suppliers, public researcher organizations, etc.) are involved.¹⁰ Networks and inter-organizational relationships are the arena in which the learning processes between producers and users take place.¹¹

In the pharmaceutical industry, innovation processes are organized in a highly regulated way. The drug development and approval process entails several stages of clinical trials after discovery and preclinical testing have been completed successfully. The pharmaceutical company is the most dominant player throughout all stages. Innovations are highly science-driven and user participation is mostly limited to patients’ and physicians’ partaking in clinical trials and the post-marketing stage. Current problems in pharmaceutical innovations include: the long time-span of drug development (and its related high costs); problems with side effects (and drug safety); restricted pools of potential drug targets; diminishing active compound success rates; diminishing numbers of drugs in the development pipeline, and; sales income as established drugs reach their end of patent cover. Novel approaches of pharmacogenomics are aimed at alleviating the long and expensive innovation process,¹² allowing for the introduction of a more demand-oriented health care model.¹³

In contrast to the “classical” pharmaceutical innovation model, patients/consumers are becoming more actively involved in decision-making processes.¹⁴ Patient organizations in general are positive about new technologies, have experiential knowledge related to their illness and wish to be involved in decision making. They have gained increasing influence in scientific agendas, either through their supply of financial support for research or by providing scientists with societal problems to address and by exerting political influence. For example, the Dutch Celiac Disease Consortium includes industry, universities and the patient community to develop safer foods and more effective diagnosis, prevention and treatment of Celiac disease.¹⁵

However, research in the Netherlands shows that the vast majority of patient organizations are not lobbying actively when it comes to influencing medical research budgets or research agendas.¹⁶ Two main obstacles for patient participation have been demonstrated: the resistance of the current biomedical research decision-making regime towards change, and the limited capability of patients to participate in, and

contribute to, decision-making in this area.¹⁷ The UK has a long history of patient participation in biomedical research starting in the mid-19th century.¹⁸ Since 1996, the advisory group Consumers in National Health System Research (named INVOLVE since 2003) has advised the government on patient and public participation in medical research. Through their efforts the UK has an extensive network of patients, medical professionals and organizations who aim for public participation in research. The James Lind Alliance is such an organization where clinical researchers and patients meet to agree on relevant research questions, such as the effectiveness of a particular medical treatment.

In the Netherlands there are some cases of patient participation, mostly in the area of orphan diseases (rare diseases). Within these orphan disease communities it is now more common practice to articulate demands, pass judgments on priorities for (public) research agendas, and channel information to companies or fellow patients.¹⁹ After years of lobbying, the Dutch Genetic Alliance (VSOP), an umbrella organization of about sixty national, disease-linked, patient organisations, is increasingly involved in national and international policy-making on genetic research.²⁰ Another example of an orphan disease community is the international Duchenne Parent Project, which was founded in the Netherlands in 1994. It has collected and spent more than three million euros on research on Duchenne muscular dystrophy at 13 different universities across Europe.²¹ Further examples of patient participation are shown in a case study on the Dutch Neuromuscular Disease Association (VSN), which focuses on patient involvement in emerging and more established therapies such as gene therapy for Pompe and Duchenne disease, stem cell therapy for Amyotrophic Lateral Sclerosis (ALS) and Enzyme Replacement Therapy for Pompe Disease.²²

The discovery of many low-penetrance/high-frequency genes correlated with health risk challenges concepts of healthy and sick, because genetically there is no clear distinction between health and disease. A high proportion of the general population are carriers of at-risk genotypes,²³ so patients are not the only (potential) users of genomics innovations. To pharmaceutical companies phenotypically healthy people become genotypic “protopatients” for which preventive strategies could be developed, such as genetic tests to anticipate future illness that is encoded in their genes. Technological innovations make gene sequencing ever faster and cheaper, which makes it possible to offer test facilities on a commercial basis. Commercial enterprises enter the market with direct-to-consumer products such as genetic tests, increasingly via internet,²⁴ and many more offer preventive DNA tests to the public at large. The regulation concerning these tests is often much less strict than regulation about medication.²⁵

Consequently, since pharmacogenomics innovations are also intended for future patients, possible “users” include healthy citizens as well. Hence, to increase the social robustness of genomics research and to realise the potential of new genomics innovations arising from it, we need to address the social, ethical and legal issues in an ongoing dialogue with a broader group of stakeholders. Since agricultural and food biotechnology has faced a negative image for some time now, especially in the EU,

although its medical applications have been generally welcomed especially by patient's organisations, and since the term "biotechnology" may not be differentiated in many people's minds, new types of interaction are required. The Netherlands Genomics Initiative (NGI), which coordinates genomics research in the Netherlands (NGI), states in this matter:²⁶

"If we really want to realise the potential of genomics we shouldn't back away from difficult topics, but approach fears and concerns with an open mind. Only then will we lay the foundations for the necessary social trust in genomics."

Fostering synergy between progress in science and its application in society is a major challenge in science communication, and requires not only public understanding of science and awareness of its new implications, but public participation in science policy as well. Patients, their representatives, physicians, pharmacists and insurance companies, and indeed the public at large representing "future patients", are important stakeholders in genomics developments. However, their role in the decision-making processes regarding new genomics technologies has not been very profound yet.

User-producer interaction: Public Participation in Science?

In the Netherlands, a total budget of 280 million euros is allocated to new genomics research for the period 2008-2012.²⁷ 25 Million euros of that has been allocated to societal research, public communication and education concerning genomics. In this way, the Netherlands Genomics Initiative (NGI) aims to contribute to a more balanced and informed public debate in which stakeholders hopefully together decide which genomics developments are needed and desirable.

The reciprocal nature of the communication aims, as explicated by the NGI,²⁸ is in line with recent views on science communication. In the 1990s authors including Brian Wynne²⁹ and John Durant³⁰ discussed the idea of a paradigm shift in science communication. Several reasons were provided for the need for such a change, often based on the desirability of scientific progress and expressed as a need to increase acceptance or trust in science and technology.³¹ It was suggested that science communication should be less limited to mass-media and should make more use of interpersonal and other more interactive forms of communication. Since then, various scholars have provided evidence for an observed shift from a transmission model of communication to a more interactive or participative approach involving the public in decision-making on scientific and technological developments.³²

The gradual changes from monologue to dialogue can be observed through the use of different notions in science communication literature.³³ Public understanding of science (PUS) built on the idea that people would more readily accept new technology and products when they understood the science behind it. Methods were merely based on traditional, one-way dissemination of information to the lay public. In this transmission or so-called "deficit model" the public is seen as a passive and monolithic mass, whose scientific literacy should be increased in order to achieve greater support for science and its financing.³⁴

In the subsequent movement of Public Awareness of Science (PAS) the public is given a more active role in the communication process. PAS aims to make people aware of the impact (costs and benefits) science can have on society. This necessitates an active process in the receiver contributing to the cost-benefit analysis, and hence more two-directional communication processes are suggested recognising that each audience has specific knowledge, experiences and needs.

Public Engagement of Science (PES) further increases the role of the receiver responding to the (social) scientific debate on the notion of knowledge as a social construct.³⁵ The latter implies that scientific progress is the result of a continuous interaction process, in which many stakeholders are involved. Accordingly, science communication should be seen as a means to optimize this mutual interaction or engagement in science. In this view, communication is a transaction process in which scientific as well as ethical and social considerations are taken into account. The role of the public however remains restricted to consultancy for decision-making about the research agenda. The activities described for this (PES) process, such as surveys, citizen juries or referenda, often reflect the limited influence on the decision-making process.³⁶ In the interaction between science experts and “non experts”, scientists still play a dominant role in the agenda-setting. In search of a more profound role for citizens, an increasing tendency towards participation of scientists and lay experts as equal partners in the communication process can be observed in both the literature and governance reports.³⁷ Transparency has now been identified as a major criterion for trust. The aim of Public Participation in Science (PPS) is therefore ascribed to improving the transparency and democratic quality of decision-making processes on the choice of scientific research, and is aimed at improving the quality of life in society. In a way, public participation presupposes a certain level of public understanding and awareness, so the experiences gained in activities focussed on these aims are all relevant for the goals of PPS.

However, as we argued in the previous section, in the Netherlands, important users of genomics developments, such as patients, physicians and healthy citizens, are not structurally involved in decision-making about new genetic technologies. Wynne³⁸ argues that this non-involvement of citizens is structural in practice, as institutions continually reinvent public-deficit explanations to prevent the technological development process from being debated publicly. In addition to this observed lack of action from the institutional side, we cannot take for granted that future users or even the majority of current users are keen to take part in “scientific decision making” and are entirely capable of doing so. In conclusion, we need better forms of interaction, and this is not going to be easy.

The Dutch Council for Social Development (RMO, The Hague, Netherlands) also concludes that, in the societal debate on human genetics, the medical-genetic discourse is still very dominant. The council strongly recommends that this debate be supplemented with “social participative discourse”, and that more emphasis be given to the consequences of human genetics developments in terms of quality of life.³⁹ This means that public questions and concerns over modes of innovation, eg, the hyping of promises of social benefits, should be taken seriously as well.

Communication then moves from the genomics-content knowledge to issues related to risk perception, regulation and ethics and involves emotions, including anxieties.⁴⁰ The key question remains, however, as to how we should, and can, shape communication in order to contribute to informed users and producers benefiting from each others' expertise and finding common ground to make decisions for the development of new genomics innovations. The next section outlines a conceptualization of such two-way communication in emerging innovations, based on theories in policy analysis.

Towards two-way communication in pharmacogenomics

For insight into ways of facilitating close interaction and knowledge integration between stakeholders, we could learn from fields where participatory approaches have been implemented. As such a field, policy analysis offers valuable reflections on the relationship between applied research and the use and development of methods in relation to policy or decision-making processes. As policy analysis is a multi-faced field in which a variety of different activities, approaches and methods have found a place, we draw on a conceptual framework developed by Mayer et al.⁴¹ This framework offers an overview of the activities and styles that claim to make up policy analysis and has been developed as a contribution to the development of interactive or participatory methods and guidance for evaluating such methods. Their analysis covers 20 exemplary cases related to technological decision- and policy-making in the Netherlands. Two of the selected projects concern genetic and medical technology: consensus conferences on genetic modification and a systemic review of disease-modifying anti-rheumatic drugs-therapy in rheumatoid arthritis.

In their classification of activities, roles and values in decision- making processes, two interaction styles explicitly focused on gathering input from scientists, medical professionals and citizens: the *interactive style* and the *participatory style*.⁴² The *interactive style* primarily focuses on gaining insight in different views and achieving mutual understanding. It implies the invitation of different stakeholders to structure problems or devise solutions in structured work meetings at which diverse interactive techniques may be used. It mainly focuses on mediation and democratising activities. The participants learn about their own views in relation to those of others, and have an opportunity to refine these. What matters is the quality of the insights obtained in combination with the heterogeneity of opinions and interests. Users can be consulted in workshops about problems they experience and the wishes and concerns they have regarding certain new genomics innovations. This way the process aims to improve the acceptance and adaptation of (future) innovations, and facilitates participants to learn from each other. For example, producers get insight into the daily context in which their product is used.

The *participatory style* aims at improving the democratic quality of decisions relevant for society and combines democratising activities with clarifying values and arguments.⁴³ It assumes that citizens have a voice and are, or become, interested enough to deliberate on substantive and politically difficult questions. Equality and openness should be promoted in communication activities by giving laymen a role

alongside other stakeholders. These are important characteristics for attaining public trust and transparency in science and technology.

Both styles of decision-making comprise three dominant communication activities: 1) clarifying values and arguments, 2) democratization, and 3) mediation. *Clarifying values and arguments* aims to bring implicit normative and ethical issues behind public policy to the surface. In the field of pharmacogenomics, clarifying values, interests and (emotional) arguments of scientists, medical professionals and patients/citizens is an important analytical step for reaching common ground and “shared decision making”. The inclusion of *lay public actors* in defining the issue at stake prevents a technological framing of the issue and increases the interest and commitment of citizens to take part in “scientific decision making”. *Democratization* focuses on the improvement of citizens’ abilities to make an informed choice and have influence on decisions of new genomics technologies. It should empower all relevant stakeholders, including industrial platforms and patient advocacy groups to engage in decision-making processes. *Mediation* activities are helpful in innovation processes when building trust between actors from different communities of practice is central. It aims at sharing perspectives between stakeholders, and enabling learning processes during which the (scientific) knowledge-gap between experts and laymen can be bridged. This step seems essential as the field of pharmacogenomics implies rather complex issues playing a role in future expectations about an emerging technology.

The next section elaborates some examples of two-way communication processes between users and producers of pharmacogenomics developments at the level of the medical practice and for society at large.

Pharmacogenomics communication processes in medical practice and society at large

As we have argued, user-producer interaction in pharmacogenomics implies participation of key users, ie, physicians, patients and the public at large, in decision-making regarding new innovations. To point out relevant activities and specific users that should be included in such decision-making processes, we will distinguish two levels at which pharmacogenomics developments will have an input: 1) the meso-level of medical practice with already established medical technologies, practices, values and routines, suppliers and health professionals (general practitioners, pharmacists), patients and patient organisations and; 2) the macro-level of society at large, with established institutions, infrastructure, and broadly shared values and beliefs among citizens in general.⁴⁴

The medical practice and the rise of pharmacogenomics

Many promises of pharmacogenomics are still speculative and revolve around its effect on future medical practice and everyday life. The Royal Society⁴⁵ has summarized some main ethical and societal concerns, based on several bioethics reports. Their report concludes that health professionals such as General Practitioners (GPs) are important actors in the pharmacogenomics era, who need to be trained in

communicating pharmacogenetic information and the associated risks to individual patients.⁴⁶ Screening, counselling and referring patients are important tasks for these primary healthcare professionals which can ensure incorporation of genomic medicine into primary care. From a public perspective, GPs are also important actors as they are regarded by the Dutch public as one of the most trustworthy professions, when compared to scientists, politicians and journalists.⁴⁷ However, their capacity to keep their knowledge sufficiently up to date and their ability to support patient choice is questioned.⁴⁸ Research underlines these concerns. Suther and Goodson⁴⁹ suggested that genomics services do not easily fit into the current practice of GPs, and in the Netherlands GP's have been shown to have insufficient knowledge of genetics.⁵⁰

Only few studies have examined primary care practitioners' (including GPs') beliefs regarding genetics and the incorporation of genomic medicine into practice. Given this dearth of empirical data, Suther and Goodson⁵¹ provided some insight in whether and to what extent primary care practitioners' perceptions of genetic medicine as an innovation influence their likelihood of adopting this innovation into primary care. Despite the anticipated advantages and consistency of genomic medicine with professional practice, the complex nature of genomics tasks seems to reduce their implementation. More than half (54.3%) of the primary care practitioners believed that staying updated on genomic-related knowledge is (extremely) difficult.⁵² Moreover, tasks such as ordering genetic testing and providing genetic counselling do not fit easily into their current practice. In line with other studies, lack of time and knowledge about genetic counselling seem important barriers for the provision of genetic services in primary care. These findings indicate that although professionals in primary care are most willing to adopt genomic medicine into their practice and strongly believe that it provides important advantages above traditional forms of medical practice, very few physicians already provide specific genetic services to their clients. Lack of time and knowledge about the complex genomics tasks seem to be important barriers to adoption.

To bridge the gulf between health-care practitioners and pharmacogenomics producers, the latter should not suffice with one-way communication (PUS) concerning their new products. Given the influence of the barriers to implementation, and the important role of primary care practitioners in the adoption of genomics medicine in primary care, they should participate early in the innovation process. Physicians are generally open to the advantages of genomics medicine, and input of their professional experience could improve the compatibility of genomics medicine with professional practice. On the other hand, more focus should be placed on enabling GPs and health-care professionals in general to understand and utilize genetic-based probability and risk assessment, and to communicate effectively about them. Health-care professionals in general are not well prepared to deal with genetic information,⁵³ but they have an essential role in empowering their patients (or their phenotypically healthy customers) for personal decision-making, based on genetic information. As Guttmacher et al argue,⁵⁴ three aspects are of main importance: the role of family history to determine the mode of inheritance; awareness of the individual information that genetic tests might give and; making appropriate referrals to a genetic specialist.

Society at large and the rise of pharmacogenomics

At the societal level, demand-oriented health care relates to the trend towards the active involvement of the patient or consumer in decision-making processes. Within the field of pharmacogenomics, medicines may be customised to the genetic constitution of groups of patients. As a result, the role of patient-advocacy groups will increase in the process of demand-articulation in a more segmented market. Also, increasing access for patients to information via the Internet is resulting in higher and more specific demands. However, so far we have argued that public participation in emerging technological developments is not yet very common and a novel yet effective and affordable approach to increase public involvement is necessary.





 Medical Practice (Hospital) 		
<u>Genomics Innovation</u>	<u>Intermediate User</u>	<u>End User</u>
Traditional genetic testing/ genetic counseling	Specialist/ genetic counselor	(Potential) patient and family members
Genomic medicine based on pharmacogenetic profile	Specialist/pharmacist/GP	Patient (and family members)
Testing for common diseases	GP/pharmacist/supermarket / patient groups/internet	Consumer/potential patient
Direct to consumer (genetic) testing		Consumer/potential patient/family members
Nutraceuticals	Supermarket/internet	Consumer
Functional food	Supermarket/internet	Consumer
 Society at large 		

Figure 1: Potential users of pharmacogenomics innovations in different contexts ranging from restricted use in medical practice (top) to free availability in society at large (bottom).

Figure 1 gives an impression of the different contexts in which genomics innovations will likely be used, with some appointed intermediate and end users. The use of genomics innovations will vary from restricted use in hospitals under the supervision of specialists to products freely available on the market. The Internet already plays a crucial role in selling products such as direct-to-consumer (genetic) tests and as a source of information about diagnoses and treatments together with their relative efficacy. Restricted use in hospitals involves obtaining informed consent from the patient. Due to the power relationship between health-care professionals and patients,

the interaction is not truly conducive to real informed consent, but the professional is required to attempt to assure that the patient really understands the choices and is not coerced. For food or chemical products, informed consent does not exist, as it is generally assumed that if the consumer purchases a product it is with consent unless and until something goes wrong. The two very different relationships are at both ends of the scale depicted in figure 1.

“Use” pertains not only to the act of consume or taking in (in the sense of swallowing a pill), but also to the act of “deciding” to exploit an innovation’s possibilities: in the case of pharmacogenomics, pharmacists and physicians both play a role in deciding whether patients should be screened or treated for a certain disease. Within this context intermediate “users” make use of the opportunities of new innovations (eg, screening for a disease or ensuring a safer and more efficient therapy).

Perception, value formation and the exchange of expectations are crucial factors in communication about new technologies. The rapid expansion of genomics research, and especially its applications in health care and nutrition, and its impact on the lives of people and society as a whole requires the ongoing involvement of all stakeholders, including the general public, consumers, patients, health-care professionals, policy makers, etc. All these potential users should be empowered to make reasoned decisions regarding the integration of genomics innovations into their daily lives. Individuals or communities should therefore gain the ability to deal with the upcoming field of genomics (eg, articulate demands, needs or restrictions). At the level of society at large, criticism of new genomics developments often comes from broader, non-patient, societal organisations, such as pro-life, environmentalist and animal-rights groups, as they are better publicists than patient organisations and thereby gain better media and political attention, and hence influence.⁵⁵ Nevertheless, Boon has found that intermediary user organisations, such as patient organizations (ie, Dutch VSN, Dutch Genetic Alliance VSOP), can be important loci of demand articulation. Such organisations influence the pharmacogenomics innovation process in several ways: overcoming market failures by articulating demands neglected by other actors; setting up scientific networks and constructing visions of the future; managing expectations and giving assistance in clinical trials, reimbursement and regulatory issues; addressing ethical and societal issues; and, ensuring the democratization of their demands by properly representing the (end) users.

Following from the above, we could argue that in the range from Public Understanding of Science to Public Participation in Science, *public communication in pharmacogenomics innovations* could in general be typified as Public Engagement in Science. Intermediary user organisations are engaged in influencing the boundary conditions of pharmacogenomics innovations, and the broadening and enriching of debates. Sometimes, they have influence on R&D agenda-setting, but this is still less common.⁵⁶ For a more participatory approach to user-producer interaction, actors in industrial, clinical and everyday life practices should be supported to specify their needs, goals and moral and ethical concerns in an early stage of emerging technologies. Clarifying the values behind these needs and concerns could stimulate finding common ground for ‘democratic’ decision-making processes regarding new

genomics innovations in which both ‘certified experts’ and non-certified or public experts can have equal input. Indeed, research on public surveys suggests a need for further analyzing moral and ethical components of science communication.⁵⁷ For example a special Eurobarometer report 225, entitled ‘Social values, Science and Technology’,⁵⁸ showed that although half of the European respondents said that decisions on science and technology should be based on an analysis of the risks and benefits of certain technology, a substantial group (41 %) thought that moral and ethical dilemma’s should have priority when decisions are made.

Concluding remarks and implications for interactive user-producer communication

Besides the *political* argument that participation of users in science improves its legitimacy and chances for successful implementation, users are an important source of tacit knowledge for producers. Users can develop new functions for technologies, solve unforeseen problems and propose or even develop innovative solutions. In a rapid expanding field of pharmacogenomics it is difficult for stakeholders to specify their needs, visions, goals and ethical considerations. Therefore users, including the general public, consumers, patients, health-care professionals and policy makers should be supported to articulate their demands and to participate in science and technology policy making as early as possible. Up till now in the Netherlands, important users of genomics developments such as patients, physicians and healthy citizens have not structurally been involved in decision-making on new genetic technologies.

This paper has articulated user-producer interaction in pharmacogenomics innovations at the level of the medical practice and at the broader societal level. To *medical practices*, pharmacogenomics will have increasing implications, but new innovations do not fit easily in daily routines of medical professionals. For genomics to effectively change the medical practice, advances in the genetic literacy of (non-geneticist) health professionals⁵⁹ need to be made. Within medical practice, decisions have to be made regarding the development and use of new genomics-based applications e.g. a diagnostic test or personalized medicine. Mutual understanding and commitment of key users, i.e. of primary care practitioners or GP’s, and producers, ie, pharmaceutical companies and scientific researchers concerning a specific innovation and the conditions for implementation should be the basis for these decisions. New participatory approaches for decision making in medicine fit into the new developments in evidence-based medicine (EBM) and could start from existing guideline development groups. EBM is a systemic approach to clinical problem solving which combines research evidence, clinical expertise and the patient perspective.⁶⁰ The Dutch Mamma Carcinoma Guideline is an example of a ‘living’ guideline which is continually being updated based on interaction between members of the Dutch Breast Cancer Association (BVN) and several medical associations. Although in guideline development research evidence is still dominant, physicians and patients are participating to improve the implementation of a genomics innovation so that it will fit in their daily routines.

Within the *society at large*, different contexts of use (see figure 1) imply that different user groups exist in pharmacogenomics innovation processes: *the majority*, i.e. mass consumers of free available products who are at best marginally interested in genomics technology and *the minority*, i.e. patients and medical professionals who are interested and motivated to participate in decision making processes regarding their illness.

As Caron-Flinterman⁶¹ has shown in the Netherlands, patients are hardly involved in biomedical decision-making processes because of their presumed lack of competence. To engage *the minority* in decision-making processes on pharmacogenomics innovations, Dutch patient organisations should play a more active role. They could inform patients in a scientifically sound way about new genomics technologies, including efficacy and safety issues as patients are mostly ignoring these issues while they are in favour of innovative medicines that could possibly cure them. Furthermore, patient organisations often negotiate, shape and communicate the social, legal and ethical impacts of a new technology. They play an intermediary role between patients and genomics developers (mediation), clarifying scientific arguments and translating patients' needs and values. One way of increasing patients influence on research agenda's is raising money and allocating this to research proposals. To increase patient participation in decisions on breast cancer research for example, the Susan Komen Fund in the United States already requires research proposals to be transcribed into a lay-version.

In contrast to direct stakeholders, the '*majority*' is far less easy to be reached and motivated to participate in decision-making processes. As the emerging field of pharmacogenomics implies rather complex issues playing a role in future expectations, it is questionable whether lay people are really that interested and knowledgeable about the issue. As Wynne⁶² has argued, raising people's interest in deliberating on substantive and politically difficult questions requests a socially and ethically informed debate about the relations between scientific knowledge and other forms of knowledge and experiences, for example with respect to health care or problems encountered in everyday life.⁶³ Such a debate should provide a consistent and rich notion of pharmacogenomics in society, based on specified needs, goals and moral and ethical concerns of a broad group of stakeholders. To guarantee the democratic quality and societal relevance of the eventual decisions attention should be paid to transparency and equal access of genomics experts and (non expert) citizens in discussion platforms, for example in a consensus conference format. As patient organisations mainly focus on management of their 'own disease', the representation of 'healthy citizens' in the debate deserves attention. In the Netherlands the Dutch Genetic Alliance (VSOP) is an important intermediary between health care users and producers. As an umbrella organisation of 60 parent and patient organisations, they represent a broader group of societal stakeholders and have developed a broad vision on the field of community genetics and genomics. From a democratic perspective they actively fight for integration of experiences and dilemma's of healthcare users in the allocation of research funds.

In this article we have given a general outline of important aspects that should be considered in shaping public participation in pharmacogenomics innovations. To optimise the social and economic success of pharmacogenomics innovations, user groups such as general practitioners and patient organisations should be invited to engage in structured mediation activities to structure problems encountered in medical practice or daily life and or devise solutions. To bridge the gulf between producers and (end-)users, we suggest that assessments on (expectations of) pharmacogenomics developments should be organized as ongoing processes involving multiple stakeholders in order to search for solutions when the articulation of the potential of pharmacogenomics in society at large is coupled with institutionalization, i.e. when heterogeneous stakeholders discuss and influence the practice and emerging future of pharmacogenomics in forums.⁶⁴ Forums are more than communication platforms, they can be spaces 'specifically designed for pre-political deliberation or other interaction between heterogeneous actors with the purpose of informing and conditioning the form and direction of strategic social choices in the governance of science and technology'.⁶⁵

Structurally, these can be organised in very different ways, from very informal but persistent networks, to highly institutionalised bodies with a clear legal organisation and differentiated sub-structure.⁶⁶ In the Netherlands, the Forum Biotechnology and Genetics (FBG) plays a role in policy consultation on biotechnology, genetics and health. Such a forum would not only be a multi-stakeholder form of governance but must also mediate between the national and international level of life sciences governance.

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