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Evidence-based policies: Lessons from regulatory science

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Abstract

In this article, various examples of controversies in regulatory science are analyzed concerning chemical and pharmaceutical products and functional foods. In these controversies, it is possible to show the relationship between epistemic policies and regulatory objectives (decision-making objectives). From an analysis of this relationship, four points must be noted that can be extrapolated to current evidence-based policy proposals: (1) The regulatory objectives determine the evidence hierarchies. (2) Evidence hierarchies determine the appropriate scientific methodology and, by extension, the scientific knowledge that will be generated. (3) The use of scientific knowledge in the formulation of public policies is an example of extrapolation, and such cases should be viewed as hypotheses whose testing requires evidence from different lines of research. (4) The suitability of a particular evidentiary hierarchy depends on what is at stake; that is, on an assessment of the gains and losses to which the policy or regulation based on such an evidentiary requirement may lead.

KEYWORDS

epistemic policies, evidence-based policy, evidential hierarchies, methodological controversies, regulation, regulatory science, scientific controversies

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For some time now, calls have been made among different groups for public policies to be based on scientific knowledge, both in their formulation and in their application and evaluation. This is a movement in favor of evidence-based policies (EBP; French, 2019; Wesselink et al., 2014). These calls are related to different areas of public policy (education, health care, poverty and development, crime and violence, the labor market, etc.), and they can be considered to have precedents in early 20th century technocratic initiatives, the proposals of the Vienna Circle, North American pragmatism with regard to the social function of science, and in Karl Popper's piecemeal social engineering. Today's version, nonetheless, is directly influenced by the evidence-based medicine (EBM) movement. It is this influence by EBM that makes EBP such a unique approach by using scientific knowledge in the management of social problems.

The aim of EBM is to identify therapies, treatments, and health procedures grounded in sufficient scientific evidence, distinguishing them from others that are only based on medical practice, without having been subjected to systematic scientific research (Sackett & Rosenberg, 1995). The objective of EBM is for the medical world to center on treatments whose effectiveness has been proven through the obtainment of empirical evidence, using the strictest scientific methodologies. This is why EBM establishes a hierarchy of scientific evidence that can be used in medical practice, in such a way that not all evidence has the same worth. More specifically, randomized controlled trials (RCTs) are viewed as crucial evidence in the recommendation of a certain medical procedure, drug, therapy, diet, etc. Evidence from observational or epidemiological studies would thus be ranked second, followed by evidence from physiological studies, bioassays, etc. (mechanistic evidence).

Although EBM prioritizes RCTs, the identification of the intervention's consequences on causal factors is a prerequisite for the establishment of causal links. In this regard, EBM can be tied in with recent proposals in the field of epidemiology (Hernan, 2005; Vandenbroucke et al., 2016). In both cases, two assumptions are made: (1) the evidence used to establish causal relations must be limited to probabilistic evidence and (2) probabilistic evidence must be related to the possibility of an intervention's success. To be more precise, evidence that does not allow for the quantitative establishment of the effects of a possible intervention on causal factors will only play a complementary heuristic role. It is not evidence that serves to establish causal relationships.

Prioritizing evidence in general and the belief that randomized trials are the best type of evidence are principles that EBP has inherited directly from EBM. One example is the 2019 Nobel Prize in Economics. The award went to Abhijit Banerjee, Esther Duflo, and Michael Kremer for their experimental studies to alleviate global poverty. These economists have promoted the use of randomized experiments in the formulation and evaluation of public policies in developing countries. Randomized experiments in this context consist of assigning a policy

(e.g., access to a microcredit) to a group that can be termed a "treatment group" to continue with the analogy with health care (e.g., to a set of villages or neighborhoods), and then comparing the results with a "control group" to which the policy is not applied. The results of these experiments serve in the design and evaluation of corresponding public policies.

The obtainment and use of scientific evidence in the shaping, application, and evaluation of public policies has generated controversy, sparking off the following responses: (1) the rejection of the very idea of using science in policy decisions in the belief that moral or ideological preferences must prevail, and that scientific research is also ideologically charged; (2) calling into question evidence hierarchies and, more specifically, the primacy of RCTs, in addition to disagreeing with the marginalization of other types of evidence (Haack, 2014; La Caze & Colyvan, 2017); (3) analyses of the limitations of the methodologies prioritized in evidence hierarchies (Cartwright & Hardie, 2012; Cartwright & Stegenga, 2011; Stegenga, 2014); and (4) the proposal of alternative forms of interaction between scientific knowledge and policy objectives to those implicit in EBP (Saltelli & Funtowicz, 2015; Saltelli & Giampietro, 2017; Sarewitz, 2000).

This article explores the second type of criticism of EBP proposals, analyzing what has happened with regard to some regulations on technological products. Using scientific knowledge in the shaping and evaluation of regulations on technological processes and products seems logical and hard to call into question. Nonetheless, it has given rise to numerous controversies in public and academic circles. Advantage can be taken of acquired experience on the drafting and application of this type of regulation, learning some lessons that can be extended to the use of scientific knowledge in decision making and, more specifically, in EBP.

CONTROVERSIES IN REGULATORY SCIENCE: SOME EXAMPLES

Since the late 1960s, technological applications and their effects have been subject to regulation by governments and parliaments.[1] Examples of this type of regulation include regulations on the risks of chemicals, the environment, working conditions, and the safety and benefits of drugs. It might be said that there is no technologically related area of people's lives that is not strongly regulated by the public authorities. Regulation is generally resorted to for the protection and promotion of public health or the environment—the two primary objectives of such legislation—although there are other types of regulations (Luján & Todt, 2018).

The drafting of these regulations and their subsequent evaluation both require the use of scientific knowledge. It is in this context that what is known as regulatory science has come to the fore. This is an activity aimed at providing guidance in decision making on the development and evaluation of regulations in the field of technological applications.

The drafting, application, and evaluation of technology-related regulations have led to different types of controversies of both a public and scientific nature. In some cases, there is public controversy prior to the regulation, while in others it is the regulatory process itself that sparks off controversy. These public controversies can be viewed as controversies over the objectives that must be guaranteed by the regulation process; that is, the regulatory objectives. There are cases where there is no public controversy, but, instead, controversy in the field of regulatory science also related to differing regulatory objectives.

An analysis of the link between scientific controversies and regulatory objectives will allow us to identify certain relevant characteristics of regulatory science (Todt & Luján, 2022). Let us look at some examples.

[1]The regulation of technological products is an activity that has been developed mainly in the United States, Canada, the EU, and Japan. That is why regulatory science can mostly be found in these countries.

Risks

In the regulation of toxic products, there has been a debate on the degree of severity of regulations and, in parallel, on the evidentiary requirements that are needed for a product or process to be regarded as posing a risk to human health or to the environment. For some sectors of opinion, prioritizing public health calls for very strict regulation due to the flexibility of evidentiary requirements. In contrast, others believe that strict regulation increases the costs for companies, thus resulting in the availability of fewer resources for the protection of public health and the environment. These different regulatory objectives influence the scientific research that should be used as a guide in the development of regulations.

Since the 1970s, the U.S. agencies that regulate technological risks have made changes to the evidentiary requirements. In the guidelines published by the Environmental Protection Agency (EPA) in 1976, evidence in humans (epidemiological studies) was considered to be fundamental in the identification of carcinogenic substances and in establishing dose–response relationships. The 1983 report by the National Research Council (NRC, 1983) insisted on the importance of evidence in humans, but it noted the difficulty involved in obtaining and interpreting it, thus recognizing that, in many cases, it might be necessary to use data from bioassays. In 1985, the Office of Science and Technology Policy analyzed the problems that epidemiological studies encounter in establishing causal relationships. The 1986 EPA guidelines recommended global assessments of evidence from epidemiological studies, bioassays, and other relevant data from short-term tests, together with the relationship between chemical structures and biological activity, although, in these guidelines, evidence in humans was still viewed as fundamental. In 1996, the EPA recommended weighing up all the available evidence: human evidence, evidence from studies with animals, and supplementary evidence (NRC, 2009).

The 21st century proposal for toxicity testing (Krewski et al., 2009; NRC, 2007) highlights the importance of mechanistic evidence in overall risk assessments. The proposed model begins with the determination of certain properties of substances (chemical characterizations). In the second stage, toxic properties are researched, mainly through in vitro cell cultures. Mechanistic evidence is considered to be relevant even with regard to the choice of dose–response model.

These changes in the evidentiary requirements are due to different reasons. Some are clearly epistemic: the characteristics of chemical products and their interaction with living organisms, difficulties in scientific research into these interactions, etc. Others are pragmatic: the time needed for certain investigations or to regulate health care and the environment in a more protective way (NRC, 2009).[2]

This interaction between pragmatic and epistemic factors can be clearly observed in extrapolation models. Using scientific knowledge in the shaping of regulations always entails extrapolation. In the case of risk assessments, the most common forms of extrapolation are from animal models to humans and from high doses to low doses. When it comes to the choice of extrapolation model, epistemic and pragmatic factors have both been taken into consideration. For example, a linear model, without a threshold, is more protective for the public health. If there is no evidence in favor of one model or another, it is reasonable to make a choice

[2]In sociological and philosophical analyses of science, a distinction is usually made between epistemic (or cognitive) and nonepistemic (or noncognitive) factors (values or virtues). Epistemic values are those that serve to justify the superiority of one hypothesis (or theory) over another. Typical examples include accuracy, explanatory power, and simplicity. Nonepistemic values, in the particular context of regulatory science, are mostly related to the promotion of innovation, as well as the protection of public health and/or the environment. I refer to the latter as pragmatic values (or factors) because they are directly related to the objectives pursued by regulation.

based on pragmatic considerations. Dose–response models are cases of extrapolation in which epistemic and pragmatic considerations interact.

Taking into account epistemic and pragmatic considerations, several authors have proposed the systematic use of short-term tests (STT; Cranor, 1995). STTs are, for example, in vitro tests with biological systems (except animals) carried out in a few hours or a few days. These tests are particularly important in establishing genotoxicity and mutagenesis.

Analyses of the relationship between chemical structures and physiological activity are now used in many jurisdictions. This entails an analysis of the structure–activity relationship (SAR) or a quantitative analysis of the structure–activity relationship (QSAR). Both methodologies lead to the classification of chemicals, based on their known structure and associated metabolic effects. The idea is that any substance with a similar molecular weight and structure to another substance already known to be toxic would automatically be classified as potentially toxic (in one of several categories). Based on this classification, the tested substance would be subject to regulation, at least provisionally, until a more exhaustive, slower investigation was conducted that could reliably establish its effects (or absence of effects). In other words, SAR and similar methodologies can be understood to represent acceptance of mechanistic information as the basis of regulatory decision making, even at the cost of less accuracy than other scientific methodologies.

One change of particular note is the reversal of the burden of proof established in the current European regulation on chemical products: registration, evaluation, authorization, and restriction of chemicals (REACH). This regulation follows the maxim "no data, no market." Industries must provide data on the safety and risks of substances, for both new substances and those already on the market (Eriksson et al., 2010; Silbergeld et al., 2015). This change in the burden of proof is justified because it is deemed to be a better way of achieving the regulatory objective of protecting public health and the environment.

The current U.S. regulation (the new Toxic Substances Control Act, TSCA) has followed the REACH approach to the regulation of toxic substances, giving the EPA more power to request information from companies. The EPA can now require more toxicity testing before chemicals are approved and limit their use based on scientific evidence regarding human and environmental health.

Drugs

In the case of pharmaceuticals, there is little public debate, not even in the case of the COVID-19 vaccine, except by anti-vaccine sectors or general critics of the pharmaceutical business. However, some authors have questioned some aspects of clinical trials. A classic in this regard is the work of Worrall, who maintains that randomization is not necessary. According to Worrall (2002, 2007), randomization is no better than other methodologies for controlling the influence of unknown variables.

Worrall's analysis is basically epistemic. Other authors use pragmatic arguments to question the symmetry of evidentiary requirements in certain cases; for example, the symmetry between a risk analysis and a benefit analysis. The question that is posed is whether the same evidentiary requirements should be applicable to both. Since it seems that what is at stake is not the same (in one case it is a health risk and, in the other, the absence of a possible therapeutic benefit), it makes sense to propose different evidentiary requirements.

Osimani (2014) advocates using different evidentiary requirements to assess the risks and benefits of pharmaceuticals. In relation to the benefits, based on Hill's (1965) criteria, Landes and others (2018) advocate analyzing and amalgamating evidence from different scientific methodologies. That is, they advocate the pluralistic approach known as the weight of evidence. Hansson (2020) believes that it is valid to tighten or relax the testing standards depending on

each particular case—for instance, the risks of new pharmaceuticals versus the substitution of a drug. Both proposals—those of Hansson and Osimani, and Landes and Poellinger—are based on epistemic and pragmatic considerations concerning the social effects of regulation.

The regulatory authorities have also made adaptations to evidentiary requirements, depending on contextual factors. For example, the European Medicines Agency (EMA) can issue conditional authorizations, based on a cost/benefit assessment. Fewer evidentiary requirements must be met for these conditional authorizations than for standard (nonconditional) ones. The first authorizations of vaccines for COVID-19 in the EU were conditional.

Food labeling

In the case of food labeling, there has been no public controversy either. However, in the EU, there is scientific controversy directly related to alternative regulatory objectives. The European regulation on health claims establishes an evidence hierarchy in which the main sources of evidence for the authorization of a health claim are intervention studies in humans; that is, double-blind controlled trials with a placebo. Other types of evidence are considered to be complementary to evidence from RCTs and they therefore do not qualify as determining evidence.

In the evidence hierarchy of the European Food Safety Authority (EFSA), intervention studies in humans, particularly RCTs, are considered to be the ones that provide the highest quality evidence. Within this category, different quality levels are distinguished, starting with fully randomized RCT studies and then intervention studies without randomization or control. They are followed by observational (epidemiological) studies, sub-classified according to their quality from cohort studies to case studies. Then there are mechanistic studies in humans, which allow us to understand the mechanisms by which the ingredient in question brings about a certain effect. The next step in the hierarchy is mechanistic studies in animals, followed by in vitro studies.

In order to establish a causal relationship between a food ingredient and a beneficial effect, EFSA deems it necessary to identify the specific beneficial effect that occurs (an improvement in some function of the human body, the reduction of a risk factor in the development of a disease, etc.). The ingredient causally responsible for the effect must also be precisely identified. That is, a specific ingredient must be unequivocally identified. Hence, evidence relating to foods as such is not admissible. Instead, the substance present in the food that brings about the beneficial effect must be determined.

The centrality of RCTs in the European regulation has several consequences: (1) there are few products with health claims on the European market; and (2) companies are only motivated to develop products with benefits that can be identified in accordance with the methodology regarded as fundamental by the regulation.

Critics of the current European regulation believe that the evidentiary requirements must be reduced so that in research on the health benefits of foods, methodologies other than RCTs can be used. For example, in some cases, evidence from observational studies or evidence concerning a substance's mode of action (mechanistic information) ought to be considered sufficient confirmation of the beneficial effects, even though these benefits might be difficult to ascertain through an RCT.

Scientists who are critical of the current European regulation have proposed what they call evidence-based nutrition, emphasizing the differences between research in the field of drugs and in food. Certain aspects of nutrition—such as low doses, continuous interaction between different substances, long time periods, etc.—mean that useful methodologies differ from those used in clinical research (Biesalski et al., 2011; Hendrickx, 2013). Faced with the notion of a single methodology, as proposed by EFSA and the EBM, these critics accept

the idea of methodological pluralism in order to tackle the challenge of obtaining useful evidence for decision making in the field of nutrition. These critics' arguments are mainly epistemic.

As in former examples, this scientific controversy is tied in with controversy over regulatory objectives. Defendants of the current European regulation believe that RCTs guarantee fully reliable regulation of nutrition, with no false information for consumers on the benefits associated with certain foods. An alternative point of view is upheld by its critics. They believe that the regulation's evidentiary requirements are too strict and that it very probably leads to a high number of false negatives. If there are many false negatives, numerous food products that are potentially beneficial for consumers will not be identified on labels as such, to the detriment of public health (Todt & Luján, 2017). While advocates of the current regulation prioritize the objective of protecting consumers from potential misinformation, critics aspire to make a wide range of foods labeled as healthy available to consumers even though some are not.

This interaction between regulatory objectives and evidentiary requirements can also be observed in the evolution of the U.S. health claim regulation. The latter is prior to the EU health claim regulation, and it has undergone various changes. These changes were due to various factors such as: (1) the need to make this regulation compatible with freedom of expression, and (2) to improve consumer understanding of the latest scientific evidence on how dietary choices can affect health. As the regulatory objectives have changed, so the evidentiary requirements have altered, and the U.S. regulation now accepts qualified health claims (Sanz Merino & Luján, 2021).

THE ROLE OF EPISTEMIC POLICIES IN REGULATORY CONTROVERSIES

Regulatory science is a type of research with one specific aim: to provide guidance in decision making.[3] It is therefore different from the science unhindered by practical constraints whose image is embodied in the "social contract for science." That is why many scientific analysts differentiate academic science from regulatory science. The differences between both types can be of differing natures; for example, deadlines for the completion of research, the relationship with the social and policy-related background framework, the role of regulatory agencies, and the pressures of interest groups.

Jasanoff (1990, 1995) differentiates between academic science and regulatory science, mainly with respect to objectives, institutions, products, time frames, as well as standards for assessing knowledge claims. From my point of view, the two principal characteristics of regulatory science (as opposed to academic science) are: (1) that in regulatory science the objective is providing advice for decision making, and (2) the involvement of regulatory agencies (government institutions). The remainder of differences between these two types of science flow from those two characteristics.

One question that is posed is whether the differences between both types might also include epistemic differences; i.e., whether there are differences of a methodological nature, in

[3]It is generally considered that the expression "regulatory science" appears for the first time in Jasanoff (1990). Jasanoff herself explains that in order to refer to this type of scientific activity she initially used the expression policy-relevant science (Jasanoff, 1987; Kurihara & Saio, 2011). However, the expression "regulatory science"was already in use in other contexts. In 1985, Alan Moghissi established the Institute for Regulatory Science in the Commonwealth of Virginia. In 1986, Mark Rushefsky talked about regulatory science in his book *Making Cancer Policy*. In 1987, the expression was used by Mitsuru Uchiyama in Japan (Kurihara & Saio, 2011). And in 1988, Liora Salter wrote a book on "mandated science": the science that is either produced and/or interpreted for the sole purpose of public policy (Salter, 1988). All these authors refer to a type of scientific activity that is aimed at advising public decision-making and in which government agencies are involved.

the grounding of hypotheses, etc. There are two main standpoints on the subject: (1) regulatory science's epistemic norms must be the same as those of academic science, with the latter acting as a model (Betz, 2013; Cox, 2015; Dorato, 2004; Laudan, 1984, 2004; Mitchell, 2004); and (2) regulatory science can be based on different epistemic norms so as to provide useful knowledge in regulation and decision-making processes more effectively (Cranor, 1995, 1997; Douglas, 2009; Steel, 2010; Wandall, 2004). When general appeals are made for the best available science to be used in public decision making, the existence of norms common to all types of science is explicitly or implicitly assumed, as upheld in the first standpoint. To defend the other standpoint, I will use the concept of an epistemic policy.

Epistemic policies establish certain norms relating to scientific research: they determine the pertinent type of knowledge by establishing the burden of proof, they select the methodologies that are most appropriate, they establish the requirements for backing up assertions through the standard of proof, and they opt for a specific evidence hierarchy, specifying the value of different types of scientific information (Luján & Todt, 2021). Epistemic policies can be analyzed in regulations or in regulatory science. In the latter, epistemic policies are tantamount to methodological decisions.

Controversies in regulatory science can be construed (or reconstructed) as controversies over epistemic policies. Epistemic policies can also be directly related to regulatory objectives. Thus, epistemic policies serve to establish a relationship between a public controversy and a scientific controversy when both types occur. In the case of risks, advocates of greater protection for human health and the environment point to the need for a precautionary epistemic policy that is not too demanding in terms of the scientific evidence that is required to support the existence of certain risks to a product. Those who are mainly concerned with the costs that a regulation can impose on companies opt for a very demanding epistemic policy so that any risks that are attributed to products or processes are well grounded. We can characterize these epistemic policies as pluralistic and monistic, respectively.

In the case of drugs, the standard stance is that the risks and benefits should be based on the same evidentiary requirements. The alternative stance is that the evidentiary requirements for the benefits can differ from those for drug substitution. The first stance aims to maximize guarantees of a drug's effectiveness, while the second prioritizes availability, at least in some circumstances. These are two alternative regulatory objectives.

The current EU health claim regulation establishes one type of evidence as being fundamental, while critics believe that other types of scientific information could also serve as a basis for regulation. As we have seen, the official stance seeks to protect consumers from incorrect information, while critics seek to maximize the availability of healthy foods recognized as such through labeling. Changes in the U.S. regulation (a change of objectives) have led to changes in the epistemic policy.

In all three cases, two epistemic policies can be identified: a monistic and a pluralistic one with regard to scientific evidence. This difference leads to either monism or methodological pluralism, and, as we have seen, these epistemic policies are directly related to different regulatory objectives.

LESSONS FOR EVIDENCE-BASED POLICY

The regulation of technology is the best example of using scientific knowledge in the shaping, application, and evaluation of regulations and public policies, albeit specifically limited to areas related to technology. In contrast, evidence-based policies are: (1) merely proposals, at least for now and (2) there are currently no government agencies (as in the case of technology regulation) that commission any relevant scientific research. However, in both cases, what we are talking about is scientific knowledge used in advising decision

making (regulations or public policies). That is why acquired experience in regulatory science serves for the assessment of EBP proposals and to anticipate some possible unintended consequences.

Policy objectives and evidence hierarchies

Our case studies show that for a much narrower problem than those addressed by public policies, more than one epistemic policy is possible, and hence there is no single body of scientific evidence that determines the regulatory options. In contrast, regulatory objectives have a decisive influence on the choice of epistemic policy, which is then reflected in the chosen evidence hierarchy. What we can glean from the aforementioned discussion of regulatory science is that the type of evidence will depend on what the regulatory objectives are. In other words, there is no multipurpose epistemic policy that can be usefully applied to any set of regulatory objectives. This means that in the field of public policies, the objectives must be established from the very outset and they, in turn, will determine the most suitable epistemic policy.

The EBP movement, like EBM, considers that it is possible to establish a purely epistemic hierarchy of evidence, without reference to regulatory or policy objectives, and it should be possible to use these hierarchies to achieve any public policy objective. Our analysis of regulatory science shows that if a particular epistemic policy is chosen, only certain regulatory goals can be achieved and only certain problems addressed.

Policy objectives, scientific methodologies, and knowledge generation

Evidence hierarchies are hierarchies of scientific research methodologies. When a type of evidence is chosen, it automatically entails the use of a certain scientific methodology that will produce that evidence, and the type of knowledge that science provides will depend on the methodology that is used. If, for example, the regulation establishes that mechanistic evidence in food labeling is not relevant, then this will affect the development of nutrition research. Knowledge of underlying causal mechanisms will no longer be gained in this field of research. The same also applies to epidemiological studies, which can be delegitimized by a regulation even though this is a widely used methodology in nutritional science.

If the use of structure–activity relationship (SAR) analysis for chemicals is established in a regulation, this will lead to a build-up of this type of knowledge or, at least, to a greater degree than before its acceptance as scientific evidence in regulations. If STTs are considered to be relevant evidence, more knowledge will be gained about mutagenesis and genotoxicity.

In the provision of scientific guidance, there is no one-way direction from science to policy making. Evidence hierarchies are established through regulatory processes, leading to a choice of scientific methodologies that ultimately determines the type of knowledge that will be built up over time. The specific terms under which scientific guidance is provided will have a decisive influence on the knowledge generation process.

We have already seen that current risk regulations make use of SAR and QSAR. Nonetheless, the mechanistic knowledge (modes/mechanisms of action) that is used in these methodologies is not the same for all categories of toxic substances. For this reason, the best-known toxic categories (carcinogens, mutagens) might possibly be well regulated, while less well-known ones (hormonal disruptors, for example) could be under-regulated. These types of situations can be improved through careful regulation. The reversal of the burden of proof introduced by the EU regulation forces companies to obtain evidence of the risks of the substances they intend to market. In this way, knowledge must be achieved that would not be obtained to the same degree without regulation.

In the case of public policies, the way in which scientific guidance influences the knowledge generation process will have important consequences. Not all problems can be addressed through the same scientific methodologies with the same degree of success. If a certain methodology is established as being the most relevant, then, only problems that can be addressed with some success through that methodology will be investigated for the subsequent provision of scientific guidance. That is, the chosen evidence hierarchy will determine the methodologies that are used, which, in turn, will condition the types of problems that are addressed in research and the knowledge that is generated. Socially relevant problems will be left out of the scientific consultancy process due to the establishment of a certain evidence hierarchy. The pragmatic objectives that give rise to epistemic policies are entrenched in these policies, and they determine the direction that scientific research takes.

In this context, it makes sense to talk about cognitive opportunity costs. Cognitive opportunity costs depend on the establishment of evidential hierarchies. If an evidential hierarchy defines a particular scientific methodology as fundamental, then research will automatically be limited to issues that can be studied by this methodology. Other topics or problems will either not be studied at all or studied to a lesser degree, and thus become invisible to science and policy. In sum, as a consequence of the application of evidential hierarchies, cognitive losses occur, some of which might turn out to be socially relevant.

Some philosophers have defended the importance of dissidence in science, using different arguments (Feyerabend, 1970; Popper, 1963; Ravetz, 1997; Solomon, 2001). The relationship between the generation of knowledge and pragmatic objectives is an additional argument in support of the idea that scientific policies promote dissident approaches, themes, and methodologies. Hence, cognitive dissidence is a way of minimizing the cognitive opportunity costs resulting from the primacy of particular scientific methodologies.

Extrapolation: confusion, uncertainty, and scientific evidence

In the field of the philosophy of science, analyses of evidence-based public policies have mainly focused on the fact that RCTs are unable to guarantee that there is no influence of any kind by variables not contemplated in the said research. The extrapolation of scientific knowledge to policy making could indeed fail due to the existence of these variables.

In the case of risk assessments, we have seen that this problem also arises in the extrapolation of laboratory research to the regulation of real practices with certain products. If extrapolation is viewed more as an empirical hypothesis, then this is an argument in favor of methodological pluralism. In risk assessments, mechanistic evidence can serve to support a given extrapolation model. As the analysis of RCTs in the formulation of public policies has shown, evidence relating to social mechanisms is also a relevant factor in extrapolation (Cartwright & Hardie, 2012).

These reflections coincide with certain philosophical analyses of the relationship between evidence from different fields of research. Several authors are of the opinion that different sources of evidence can serve to support scientific hypotheses (Haack, 2014; Hacking, 1983; Russo & Williamson, 2007; Soler, 2012; Wimsatt, 1981). Hence, the best available science does not mean opting for a single methodology able to afford the best possible results (the highest standard).

The epistemic relevance of what is at stake

In the case of drugs, Osimani and Hansson base their arguments on what is at stake. That is, it is possible to modify the evidentiary requirements depending on the analyzed costs and

benefits, taking into account the consequences of possible errors and opportunity costs. This is why an argument can be made in favor of establishing different evidentiary requirements for risks and benefits. This is what the EMA does with conditional drug approvals.

In this context, it is also useful to compare the European regulation on chemical products with the food labeling one. Very strict evidentiary requirements, in the case of chemicals, would mean that some toxic products would be in circulation on the market. Because this is deemed to be undesirable, a permissive standard of proof would enable some products to be rated as having adverse effects on human health and the environment. In the case of food, the situation would be as follows. Very strict evidentiary requirements could lead to the removal of potentially beneficial information for consumers, although, at the same time, they would be assured that products labeled as healthy really were. More permissive evidentiary requirements would result in some products being tagged as healthy when they were not, but they would still be available to consumers. In the regulation of health claims, what is at stake is not the same as it is in the case of risk regulation.

Advocates of evidence hierarchies, in general, and EBP, in particular, do not take into account the possibility of modifications to evidentiary requirements, based on assessments of the possible costs and benefits. Regulatory science shows that this is a reasonable alternative in the achievement of certain regulatory objectives. This can be extrapolated to EBPs. The evidentiary requirements should depend on the consequences of the said policies or regulations, and not on a priori appraisals of the best available scientific knowledge.

CONCLUSIONS

Scientific knowledge is a fundamental tool in the shaping, application, and evaluation of public policies. Advocates of grounding public policies in scientific knowledge are right in stating that, in many cases, socially relevant decisions are made solely on the basis of intuitions or ideological preferences, and this is why, in many cases, failure or unintended consequences are guaranteed. There is no sense in abandoning the use of knowledge from scientific research when important social problems are addressed.

When scientific knowledge is used in decision making, there must be adequate understanding of the interaction between the generation of knowledge and policy or regulatory objectives. The usual assumed notion of a separation between the generation of scientific knowledge and the latter's possible applications poses important problems. This is the case when the notion of the best available science or the social contract for science are invoked.

Regulatory science is the best available example of the use of scientific knowledge in decision making. Its analysis thus serves to anticipate possible problems that might be generated by the use of scientific knowledge in policy making when both areas are assumed to be completely separate. There are basically two different lessons that can be learned from this analysis of regulatory science. In the first place, there is clearly no single methodology or single type of evidence that is useful in achieving different public policy objectives. The specific policy objectives will determine the type of evidence and relevant methodology that are required. Second, by determining the relevant methodology, the objectives influence the type of knowledge that science will generate for the formulation of policies. This analysis of regulatory science shows that the relationship between policy objectives and the generation of knowledge is not unidirectional.

The regulatory or policy objectives in question will determine the type of appropriate evidence, the relevant scientific methodology, and the type of knowledge that is generated through the choice of a specific epistemic policy. Epistemic policies further consolidate the pragmatic objectives that gave rise to them, guiding scientific research in a certain direction. Hence there is feedback between policy objectives and scientific research.

In the case of EBP, it is important to point out that when the use of a certain epistemic policy is based on a priori appraisals of the best possible knowledge and best possible methodology, only certain policy objectives will be achieved, only certain social problems will be scientifically investigated, and only certain types of policy interventions will have the necessary supporting evidence.

By choosing one epistemic policy over another, this will have different consequences of a social, policy-related, scientific, and innovation-related kind, among others. An analysis must be made of these possible consequences before a particular epistemic policy is chosen and after its regulatory implementation. In assuming that there is always one best research methodology or type of evidence, the possible consequences of such a decision can be overlooked.

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CONFLICT OF INTEREST STATEMENT

The author(s) do not have any conflicts of interest to declare.

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