3.3.1 The impact of STI on society

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Abstract

High-impact science, technology, and innovation have transformed the way society works. Although the contact between science and technology and society has increased, the contributions of science and technology and its implementation thereof still takes a long time. In order to promote science, technology, and innovation that can transform society, it is essential to invest in science and technology in the short-term in order to address the social challenges we face, as well as in the medium- and long-term. However, whether such changes in society through science, technology, and innovation contribute toward improving society's well-being is not self-evident. In the Japanese view of science and technology, there is little awareness that science and technology are making society better. In fact, science and technology have the potential to raise socioeconomic, ethical, and social issues. This paper explores the impact of such science, technology, and innovation on society using examples from the health and medical fields.

Keywords

Social implementation, science and technology perspective, technology transfer, health technology assessment, clinical application

1 Japanese views on science and technology

Various surveys have been carried out in Japan to measure people's attitudes toward science and technology. These include the nine public opinion surveys on science, technology, and society conducted

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by the Cabinet Office since 1967 [1]; the Internet survey conducted by the National Institute of Science and Technology Policy (NISTEP), a national research institute under the direct control of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) [2]; the National Character Survey conducted by the Institute of Statistical Mathematics every five years since 1953 [3]; and the World Values Survey (WVS) conducted by Inglehart at the University of Michigan [4]. Although there are problems in international comparisons caused by the low response rate in Japan, and the tendency of Japanese people toward understatement and avoiding extreme answers, survey research provides insights regarding the Japanese view of science and technology (Ryozo Yoshino et al., 2015). According to survey data, the Japanese view of science and technology is characterized by the following two points.

First, there was a change in attitudes during the 1970s. Indeed, not only did Japanese people's attitudes toward science and technology change in the 1970s, but the way in which they viewed things in general. According to the surveys on the Japanese national character, the opinion that "human beings should conquer nature in order to be happy" declined, while the opinion that "human beings should abide by nature" began to increase after the 1973 survey. Moreover, 50 percent of the respondents—the same proportion as current respondents—agreed that "as science and technology develop, we become less human."1 According to the Cabinet Office's "Public Opinion Survey on People's Lives" [5], a similar proportion of respondents said that they wanted to focus on material wealth as those who said they wanted to focus on spiritual wealth in 1970, with the latter subsequently increasing. At the time, Japan was under pressure to deal with two oil crises and growing pollution problems. It was against the backdrop of these social conditions that the linear model (Kobayashi Shinichi, 2012), which had prevailed during the period of high economic growth and held that basic research based on the judgment of scientific and technological experts would lead to the solution of social problems, was rejected in the 1970s.

Second, the Japanese view is characterized by a relatively low estimate of how science and technology has improved the world compared to other countries. The World Values Survey (6th wave), conducted between 2010 and 2014, asked respondents to rate on a ten-point scale whether the world would be better or worse off as a result of science and technology. Among the fourteen OECD countries surveyed, Japanese respondents gave the second lowest rating after Mexico. A similar trend was observed in the fifth wave of the survey conducted between 2005 and 2009, when Japan's ratings came in the second lowest after Hungary among the seventeen OECD countries surveyed. However, this tendency is not necessarily related to an awareness of the negative effects of science and technology. (Kuriyama Takayuki et al., 2011). In a public opinion poll asking whether the development of science and technology has had more positive or negative aspects, only 40% of Japanese respondents were aware of the negative aspects. Conversely, in countries such as the UK, Germany, and the Netherlands, where science and technology is more likely to be seen as having improved the world compared to Japan, more than 50 percent of respondents were aware of its negative aspects [6]. It is not only the negative factors such as the safety and risks of science and technology that lead to a distrust of science and technology. An analysis of people's distrust of science and technology in the UK (Kobayashi Tadashi, 2012) shows that dialogues about ethical, legal, and social issues were desirable when it came to communication between science and technology and society. In the future,

it is expected that how people in Japan evaluate science and technology will be improved by enhancing opportunities for science and technology communication.

2 Winners and losers in the evolution of science and technology: Trends and experiments in the health and medical fields

Academic and research institutions are expected to develop innovative technologies and return them to society. However, the impacts of the evolution of science and technology are not only beneficial. Indeed, novel technologies have the potential to benefit many of their target populations while disadvantaging other populations and society as a whole, throwing up ethical, legal, and social implications (ELSI).

Take for example the social implementation of a new cancer treatment drug originating from Japanese researchers. Dr. Honjo Tasuku and his colleagues at Kyoto University, together with Ono Pharmaceutical Co., Ltd. developed a new therapeutic drug, nivolumab, which restores immune function against cancer cells (Ishida et al., 1992; McNutt, 2013; Topalian et al., 2012). It was launched in Japan in September 2014, as a treatment for malignant melanomas, a rare form of tumors, ahead of the rest of the world, and its treatment scope was expanded to include non-small cell lung cancer in December 2015 (Brahmer et al., 2015). As a result, approximately 50,000 patients per year experienced significantly prolonged survival. In its interim results for September 2016, Ono's sales rose 94.7 percent over the same period the previous year, with both sales and profits reaching record highs [7].

However, the effects of this medical breakthrough on society have not been uniformly positive. The cost of nivolumab per adult male per annum is approximately JPY 35 million. It was found that if all eligible patients used nivolumab, the annual cost of the drug would be approximately JPY 1.75 trillion [8]. Under Japan's high-cost medical care system, patients pay just a small percentage of their own costs, with the remaining portion covered by medical insurance benefits and taxes. As such, an innovation that has been a godsend for one group with a specific disease has become a financial threat to Japan's health insurance system, which supports many other patients and citizens. In response, the Ministry of Health, Labour, and Welfare (MHLW) decided to significantly reduce NHI prices by 50 percent in February 2017, without waiting until 2018 for the usual NHI price revisions [9]. Nevertheless, these out-of-regulation revisions may also have undermined the predictability of pharmaceutical companies' operations and discouraged them from investing in new innovations for the benefit of current and future patients.

As with nivolumab, increasingly sophisticated and expensive medical technologies [10] are one of the factors that increase national healthcare costs by hundreds of billions to a trillion yen per year, calling into question the sustainability of the universal healthcare system (Nishigori Tatsuto et al., 2015). In addition to economic issues, life science innovations like the clinical application of iPS cells raise ethical and legal issues. It is also important to remember that any new medical technology carries the risk of adversely affecting the target population. The implementers of science, technology, and innovation need to clearly recognize that the effects of such developments are not uniformly beneficial, but may also raise ELSI among certain groups or society as a whole.

Technology assessment supports social decision-making by predicting these social impacts at a relatively early stage of technological development (E. Shiroyama et al., 2013). Health Technology Assessment (HTA) is one such attempt in the medical field, with comparative utility analysis a typical method in this respect. It evaluates cost-effectiveness, that is, how much an increase in costs can improve life expectancy and quality of life (McCabe et al., 2008; Nishigori Tatsuto et al., 2015). Using this method, which is used in other countries and is about to be introduced in Japan to evaluate the cost-effectiveness of high-cost medical technologies such as nivolumab [11], will enable society to make effective use of its limited resources and fairly evaluate valuable technologies. Such evaluations are expected to further encourage breakthrough innovations.

It is also essential that HTA not only involves health care professionals but patients and the general public (Menon and Stafinski, 2011). Individual patients and citizens, not healthcare professionals, should judge whether the effects of a new medical technology are positive or negative. In the UK, a leading HTA country, patients and citizens are actively involved in HTA under the Patient and Public Involvement Policy, which views patients as experts in living with illness rather than as medical laypersons [12, 13].

According to the Fifth Science and Technology Basic Plan, the relationship between society and science, technology, and innovation should be deepened from the conventional relative relationship to one of "co-creation" among various stakeholders. By promoting standardized activities such as HTA, in which the impact of science and technology is predicted, evaluated, and judged from multiple perspectives, stakeholders can interact and collaborate with one another, thereby fostering co-creative science, technology, and innovation in Japan.

3 The extent to which science and technology contribute to society from the perspective of the clinical applications of medical research

Although the natural sciences have developed in isolation from actual practice, science and technology policy can no longer ignore its relationship with society, particularly insofar as much of government R&D expenditure in OECD countries is spent on socioeconomic objectives, such as national defense, health, and environmental protection (Rihiko Iwahashi, 2016).

In 1999, the World Science Congress adopted the Universal Declaration on the Use of Science and Scientific Knowledge as a new mandate for promoting science for the twenty-first century. The fourth chapter, "Science in and for society," states that scientific research and the knowledge it generates must be used for the welfare of humanity, human dignity, and respect for the global environment [14]. In Japan, the Fourth Science and Technology Basic Plan, formulated in 2011, set forth the idea of realizing "policies that are developed in cooperation with society" [15]. In light of the increasing complexity of domestic and international challenges, the Fifth Science and Technology Basic Plan, developed in 2016, included "addressing economic and social challenges" as one of its four pillars [16].

The 2015 White Paper on Science and Technology introduces the changes in people's lives brought about by scientific and technological advances in Japan over the past decade alongside the role played by the government. Eight cases were presented, including photocatalytic technology used in exterior house

coatings, the world's first fully farmed bluefin tuna, and drugs for hypercholesterolemia, many of which took several decades from research germination to implementation [17].

It is well-known that basic medical research takes a substantial amount of money and time to reach clinical application. Indeed, a previous study reported that of the articles published in the top five journals between 1979 and 1983, twenty-seven had reached the clinical application stage after ten years (Contopoulos-Ioannidis et al., 2003). We examined articles published in the eight leading journals between 1989 and 1993, as the emergence of new research areas and problems may have changed the rate and time required for reaching the clinical application stage. In doing so, we found that the rate of clinical application decreased while the time to clinical application increased compared to previous studies (Hanaki et al., 2016). This suggests that research funding should be allocated based on the content of the study, and not on the journal in which it was published.

In the future, countries like Japan (primarily developed countries) are expected to face issues resulting from socioeconomic changes that need to be solved, such as demographic changes due to declining birthrates and an ageing population, resource shortage issues, and environmental problems [18]. Science, technology, and innovation are expected to solve these problems and contribute to society. At the same time, it is necessary to support basic research that does not immediately lead to practical application, but which may lead to future innovations. In this respect, care must be taken when allocating limited research funds.

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