Chapter 3

The Process of Technology Transfer

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INTRODUCTION

Technology transfer, as an explicit concept, has been used in the health field only in the last decade. Its increasing use has paralleled the increasing development of policies related to medical technology. Definitions are numerous, ranging from the narrow and more specific to the broad and general, The common thread among them, however, is that technology transfer represents a process that includes a series of events. It cannot be described as one activity or one point in time, although discrete activities can certainly be the focus of the process.

The first type of definition is exemplified by Brown, et al. (10), who define technology transfer as "instances where the given technology moves from one situation to another, which may require changes in the technology, the context to which it is moved, or both . . . . [It] diverts the movement of the technology toward increasing specificity [which occurs in the innovation process] by either changing the technology to fit a new application or, conversely, by changing the specificity of an application to fit the technology." The second type, the broad definition, is represented by Dans (18), who defines the term "technology transfer" as "shorthand for the diffusion of technology from its discovery to its appropriate application. "

The National Institutes of Health (NIH) stated definition (57) falls into the broad category: "Technology transfer involves the transfer of research findings to the health care delivery system. " Yet this definition has been made narrow in its operation by a focus on only two activities—the development of technical consensus on new interventions and the demonstration of these new technologies in the health care system.

As with its definition of medical technology, ' OTA defines technology transfer broadly. Medical technology transfer is the process of moving medical technologies from their creation to their application in clinical practice.** It is the means by which medical technologies move through their lifecycle, beginning at the stage where new knowledge is translated into new technology through applied research and ending at the stage where it is applied to the population. Figure 2 depicts the technology transfer process. Though represented in a linear fashion for the purpose of discussion, the process is rarely, if ever, linear. Technology transfer is related to the innovation process*** and can be viewed as the subset of that process that is concerned with innovations that are technologies.

Technology transfer occurs either informally or formally. Informal technology transfer refers to transfer that happens without directed efforts toward putting a technology into clinical use. It usually occurs prior to evaluation of the technology, through activities such as personal experience, peer interaction, and publications. Formal technology transfer is a directed series of activities designed to facilitate appropriate application of the technology. These activities are the components of the ideal model of the lifecycle of medical technology development and use, including evaluation activities, demonstration and control programs, and directed education of the professional and lay communities in the use of the new technology. All types of evaluation, then, including technology assessment, are an important part of the formal technology transfer process. Information dissemination activities assist both informal and formal technology transfer.

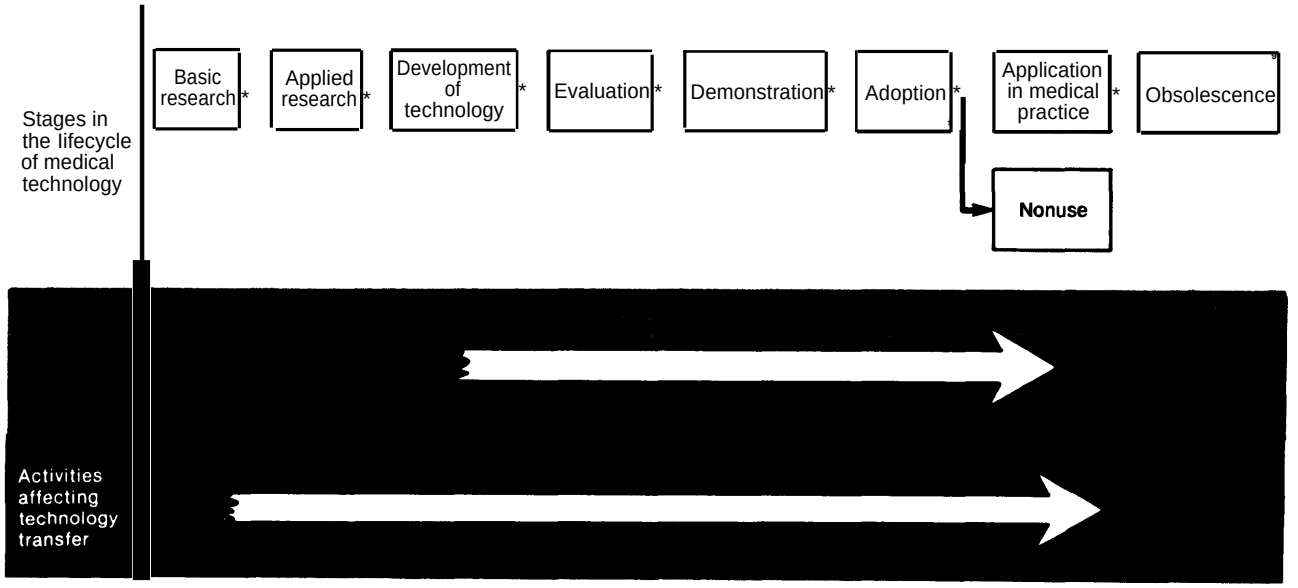
In general, the overall objective of studying technology transfer is to develop (and refine) methods and activities to affect the process

*See ch.2.

* *In the context of this report, the term "technology transfer" actually refers to "medical technology transfer. " "Medical technology transfer" could also be called "health-related technology transfer;" the important point is that the process occurs in the health care system.

**For a discussion of the innovation process, see *Strategies for Medical Technology Assessment* (92.

Figure 2.—The Process of Technology Transfer



SOURCE: **Office of Technology Assessment,**

—either to accelerate its pace, to slow it down, to modify it, or to stop it entirely. For technologies showing promise early in their lifecycle or for those evaluated to be useful in certain clinical applications, it is desirable to hasten the process. On the other hand, for technologies not yet evaluated or for those with early indications of being inefficacious or even harmful, it is desirable to slow or, in extreme cases, stop the process.

The specific objective of looking at technology transfer for any particular technology will vary according to that technology's state of development—emerging, new, existing, or new application of existing technology. * In any of these cases, however, there is a need to identify the technologies whose movement through the transfer process will be accelerated or slowed. When evaluating the technology transfer process, mechanisms for identification of technologies (at any of the stages of development) should be assessed. These mechanisms at NIH are presented in this report.

The technology process will also vary according to its "clients'' -those who learn about the technology and actually put it to use. Clients of the process include: other scientists, who develop the technologies further or discover new applications; industries, who produce, test, and market hard technologies (e. g., drugs and devices); physicians and other health personnel, who apply the technologies; patients, who receive the benefits (and risks); policy makers, who use the information to make decisions affecting future technology transfer; and the general public, who may fall into the other categories at any time.

*Existing technologies are those that have already been "transferred. " However, they may, as in the case of radical mastectomy, be candidates for transfer activities that "should have been" conducted prior to their adoption. Once evaluated (or reevaluated), transfer activities can be used to influence adoption under the very specific circumstances.

FACTORS AFFECTING TECHNOLOGY TRANSFER

There is a large body of literature concerned with the diffusion of innovations; by definition, then, it is also concerned with medical technology transfer. It can be divided into three sources:

1. sociological research on the diffusion of innovations in social systems;
2. the effects of communication variables on attitudes and behavior; and
3. the scattered, nontheoretical literature in medicine, consisting of descriptive studies of dissemination and adoption of different medical innovation *(92).*

Factors affecting technology transfer can be placed into categories, including characteristics of the technology, characteristics of the technology developer, characteristics of individuals using the technology, characteristics of organizations (and their members) using the technology, attitudes, research policies, and regulation and reimbursement policies. As is usually the case with categorization in this area, these categories are created more to facilitate discussion than to convey a sense of discrete sets. In fact, there is a great deal of overlap and interrelationships among them. For example, factors in the last three groups (which are mostly "external" factors) often influence factors in the first four groups ("internal" factors). And although there have been many studies about these factors, the only consensus is that there is much more to learn.

The primary reason for understanding factors which affect technology transfer is to use the knowledge to improve transfer activities. However, understanding these factors and their interrelationships heIps to explain why the best efforts by public and private organizations to affect technology transfer do not always work. In the remainder of this section, the factors will be described. The purpose is to place NIH activities, described in chapters 5 through 7, in perspective; thus, the description is not complete.

Characteristics of the Technology

The nature of the technology itself will affect the technology transfer process. Previously mentioned characteristics include the stage of its development (emerging, new, existing, new applications of existing technology) and its medical purpose (preventive, diagnostic, therapeutic, etc.) Other characteristics include its complexity and perceived effectiveness (18), its initial success or failure when tested, and its potential for marketability (where an actual product is the objective) (99).

Characteristics of the Technology Developer

If the new technology developer is an individual, his or her characteristics may influence technology transfer. They include personality, degree of fame, access to other scientists, and ability to appreciate the importance of the discovery (99). For example, an unknown physician named Hammer diagnosed coronary artery occlusion in one of his patients. His published report in 1878 received no attention, and it was 34 years until another scientist named Herrick made the same discovery. Access to resources is another factor important for individual and organizational technology developers. For organizations, particularly companies, their size may influence their ability to develop new technology. It has been found that small companies contribute most to innovation in the early stages of a technological field, but large companies dominate by the time the field matures *(92).*

Characteristics of Individuals Using the Technology

The effects that characteristics of individual users have on technology transfer have been widely studied, particularly for physicians. Factors influencing transfer include amount of and access to information on the technology; degree to which the individual can be described as cosmopolitan or local; amount of education; preference for the goal of quality health care rather than economic efficiency (10); and the degree of openness to trying new ideas (99).

A crucial distinction has been made between communication that informs physicians about novel technologies and that which influences physicians to act. Clearly, both types are part of the technology transfer process. The most important source of new knowledge about improvements in medical technologies is professional literature. However, physicians cite professional colleagues more often as sources they turn to when actual implementation of new procedures is contemplated. Physicians of greater prestige tend to hear about innovations sooner; they are mentioned by their fellow professionals as influential sources on the medical practice of others *(92).*

Characteristics of Organizations (and Their Members) Using the Technology

If the technology user is an organization, its organizational structure as well as characteristics of individuals within it will affect technology transfer. There has been a great deal of sociological research in this area, and there are nearly as many theories as there are studies. Not surprisingly, the results have been conflicting. No attempt will be made here to resolve the conflicts, although it should be noted that characteristics of the technology being adopted may affect the effects of the organization.

Greer (29) summarized some of the work on organizational structure variables. Size and resource base are important variables, In general, the larger the organization and the greater its resource base, the more likely it is to adopt innovations. Yet the effects of these variables are often overriden by others—organizational complexity, centralization of decisionmaking, and formalization of rules and behavior.

Attitudes

Attitudes is a class of factors influencing the technology transfer process at all stages. Favorable attitudes can speed up the process, while negative attitudes can slow it down. Attitudes of the individuals potentially adopting or developing a new technology will interact with the attitudes of the society around those individuals in affecting the decision to develop or adopt. For example, if the general attitude of society regarding technological intervention in the birth process had been negative, it is possible that the widespread use of electronic fetal monitoring prior to demonstration of its efficacy would not have occurred. Similarly, that technology has been a relatively recent focus of interest and concern (4), in part because of current increasingly numbers negative attitudes toward such intervention. A final point to be made here is that it is unlikely, if not impossible, that contribution of attitudes to technology transfer will ever be quantified. However, their importance must be recognized.

Research Policies

While it is true that various types of research are actually part of the technology transfer process, it is also true that several types of research policies affect the process. First, the way total research funds are distributed among the stages of the transfer process will affect the transfer which occurs. While basic research is not actually part of technology transfer, it provides the knowledge base for technology development (several examples are provided in ch. 2). Thus, the relative amount of funds devoted to basic research will affect the amount of knowledge ready to be applied, the amount of funds devoted to applied research will affect the *amount* of technologies to be developed and transferred, and so forth. The amount of funds available for evaluation and demonstration will not necessarily affect the amount of technologies transferred, but it will affect the amount of technologies that are

transferred *appropriately* (i. e., those that are transferred after being shown to be efficacious, safe, cost effective, etc.).

Second, the criteria used for setting research priorities, both overall for an organization and within any program for specific projects, will affect the types of technologies transferred. Within an organization, research programs could place priority on filling gaps in knowledge in areas that:

1. Americans fear most (such as cancer);
2. are associated with a greater loss of "quality adjusted life years;"
3. have the greatest cost impact on individuals or society but do not necessarily affect the greatest number of people (such as renal dialysis);
4. have the greatest cost impact as a result of affecting the greatest number of people;
5. have the greatest opportunity for study;
6. happen to be in vogue scientifically or politically; or
7. have the greatest impact as a result of a combination of high cost, high morbidity, and high mortality (18).

Within programs of an organization, projects can be selected according to scientific merit, potential usefulness in clinical applications, political popularity, total cost, and past contributions of the principal investigator, among others.

Finally, the places where research is conducted will affect technology transfer with respect to the degree to which the research organization is plugged into the professional literature or into clinical practice. For example, a top medical school associated with a top teaching hospital is more likely to have a new procedure move into widespread application than a relatively unknown clinic.

Regulation and Reimbursement Policies*

Regulatory actions and more informed reimbursement decisions help to insure that emerging technologies are efficacious, have acceptable risks, and are used appropriately (e. g., are used cost effectively). Private industry determines which drugs and devices it will develop primarily through market-based criteria. To address perceived deficiencies of the market approach, governmental actions infuse additional criteria based on social and political concerns. These governmental actions have generally been regulatory in nature, concentrating on the costs to our health, safety, and environment. Because these costs are diffuse, they can be addressed through collective, governmental actions but not as effectively by individuals. Government's role as a purchaser of technologies, of great significance in health care because of government's role as insurer, has also led to a need to minimize reimbursing for the use of ineffective technologies. This role has also created a need for ways to help decide which among the array of technologies are the most appropriate. In the regulatory process, diffusion into the marketplace is unquestionably slowed, and some technologies are filtered out. Reimbursement policies can also slow (or speed up) diffusion. Slowing the diffusion of new technologies may allow for more informed and timely decisions before widespread use.

The effect on innovation (or technology transfer) from regulatory and reimbursement policies is not simply one of whether the process is inhibited but also whether the alterations in it are unintended or undesirable. Government support of R&D has long sought to alter the process, most notably to accelerate its pace and push it in certain directions. Regulation, particularly when it alters the competitive market, can alter the direction that innovations take. Reimbursement policies probably have more effect on the pace of the process. There is general agreement that competition among medical care providers is typically not based on price. Under current reimbursement policies, there are incentives to adopt all available diagnostic tools and to pursue any therapy anticipated to have any value, especially in hospitals. Third-party coverage currently accounts for about *90* percent of expenditures for hospital care. As the price of technology has little effect on providers and patients under existing health insurance ar-

● This discussion is adapted from *Strategies for Medical Technology A Assessment* (92)

rangements, a greater adoption of technology can be expected to occur (and has actually occurred in many cases) than under more price competitive reimbursement arrangements.

At a simple level of comparison, recent changes in current regulatory and third-party reimbursement policies can be thought of as approaching some middle ground from opposite ends of the spectrum. Regulation purposefully slows down the innovation process, particularly at the diffusion stage, and modifications are now being sought (e.g., in premarket approval requirements for drugs) to insure that this slowing of the innovation process is no more than necessary to achieve the regulatory program's objectives. Current reimbursement policies, on the other hand, are seen as boosting the diffusion of new medical technologies beyond what would take place under more price competitive systems, and reforms are being aimed at constraining the adoption process.

Because regulation's purpose is to infuse social criteria into judgments of a new technology's worth, conclusions based on the economic impact of regulatory requirements must be reached with caution. Regulation is expected to change the innovation process. The issues are whether the specific changes were intended and whether the benefits of regulations are worth the price paid in resulting alterations of the innovation process.

In reimbursement policy, a need is to infuse more price sensitivity into the dissemination and use of new medical technologies. Taken together with the regulatory approach, these changes would theoretically: 1) allow into the marketplace innovations which have met social criteria of worthiness, and 2) make it possible for those new technologies which have passed the regulatory test to then compete with each other on a price basis. Curtailing excessive demand by a more price-sensitive approach, however, means changing the conditions of the current medical technology innovation process. Again, the question here is whether such major changes in the demand for new medical technologies will affect the innovation process in unintended and undesirable ways.

METHODS FOR MEASURING AND EVALUATING TECHNOLOGY TRANSFER

Methods for measuring and evaluating medical technology tranfer as a coherent process are not nearly as well developed as methods for measuring the effects of any one part of the process. There are methods available to measure the way physicians adopt a new technology, to evaluate the efficacy of a procedure, or to determine if a demonstration program met its stated goals. Yet there are no well-developed and highly structured research methods that can be used to answer questions about the translation of science to health care (99).

The most promising approaches are refinements of case study methods like those used to trace the scientific lineage of major technological breakthroughs. The most prominent examples of past work are the studies (and their follow-ups) by Comroe and Battelle-Columbus Laboratories for the President's Biomedical Research Panel (99). These past studies, though, do not usually extend beyond the development stage of the process to implementation in medical practice.

An alternative to the case study approach is the assessment of activities which occur as part of the technology transfer process. In this approach, the focus is on the environment in which the technology is transferred rather than on the technology itself. The major weakness of this approach is that it does not look at the entire process at once; however, by examining all activities in one study, the effects of this weakness are lessened. In addition, the connection between the activities and the actual transfer must be assumed, although the influence of other factors is well known. The major strength of the method is the potential for examining any activity in depth, including its relationship to other methods. It is also most useful when the focus of study is one particular organization.